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July 1988-June 1989

Illinois Department of Energy and Natural Resources

STATE GEOLOGICAL SURVEY DIVISION

ANNUAL REPORT

to the

BOARD OF NATURAL RESOURCES AND CONSERVATION

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1988-89 HIGHLIGHTS AND SUMMARY

The Illinois State Geological Survey, after approval from the Board of Natural Resources and Conservation, reorganized into three branches: Mineral Resources and Engineering, Environmental Geology and Geochemistry, and Technical and Administrative Services.

MINERAL RESOURCES AND ENGINEERING

• The value of fossil fuel production (both coal and oil) decreased significantly in Illinois in 1988. These decreases were offset only partially by gains in the value of production of industrial sand, stone, sand and gravel, and other minerals. The overall value of mineral production dropped from $2.6 to $2.4 billion per year.

Coal

• Nuclear energy surpassed coal as the prime fuel for electricity generation in Illinois during 1988. The amount of coal produced was 56.6 million tons in 1988 compared with 60.8 million tons in 1987.

• Reassessment of the availability of coal resources in Illinois was initiated as part of a continuing effort to build a national database on coal resources. Previous studies identified 190 billion tons of coal resources in the ground, but the new assessment will identify the coal recoverable under existing geological, economic, environmental, technological, and legal constraints. Preliminary indications are that less than 20 percent of Illinois coal resources are recoverable under these constraints.

• Stratigraphic information from almost 3,500 holes was added to the Coal Section's database this past year, further enhancing the State's own database.

• Maps of the Dekoven and Davis Coals, generated from the Survey's database of more than 1,500 drill holes in Saline and Gallatin Counties, form the basis for a coal resource evaluation in those areas.

• Survey scientists developed a method for determining the organic sulfur content in select coal maceral particles. With this method, an optical microscope is used to identify macerals, which are then analyzed by a scanning electron microscope (SEM) equipped with an energy-dispersive X-ray spectrometer (EDS). From analysis of five coals, results indicate that the mean organic sulfur content is generally highest in sporinites, lowest in various inertinites, and intermediate in vitrinites.

• The Applied Lab has been investigating advanced froth flotation of fine coal as a precombustion desulfurization method. The method can be used to clean finely ground coal or to recover coal from the fine-waste stream of a preparation plant. The most cost-effective reagent package for preparation plant waste streams used alcohol/kerosene with small doses of surfactant added to increase flotation rates. For plant-washed samples, alcohol/surfactant systems were found to be an effective alternative to commonly used alcohol/kerosene systems. Comparison of results for given reagent systems used in subaeration cells and in a column showed greater ash and pyrite removal in the column than in the subaeration cells.

• Wet-grinding of coal to -200 mesh followed by hot-water leaching of a resulting filter cake of the ground coal resulted in a 50-percent reduction in the chlorine content. This process is effective in removing chlorine from Illinois coal.

• Design goals for a continuous-feed unit (CFU) were established as a part of a desulfurization project using carbon monoxide and ethanol. The CFU will combine a three-step process that removes inorganic and organic sulfur from high-sulfur coals by using consecutive carbon monoxide and ethanol treatments. A first-phase contractual agreement was negotiated, and experimental work is underway (at the University of North Dakota Energy and Mineral Resources Center) for adapting the carbon monoxide/ethanol technology to fluidized-bed reactors. Work also began on a one-step process, for which a patent is pending.

• After analyzing a market research study on the demand and supply of various by-products from the carbon monoxide-ethanol desulfurization process, researchers recommended that the current flow process be modified to produce only acetaldehyde and sulfur, converting H_2S to sulfur and carbonyl sulfide to some other useful compound.

• Stable isotopic ratio studies support the conclusion that elemental sulfur extracted from weathered coal by perchloroethylene (PCE) is an oxidation product of pyrite and is not produced by some transformation of organic sulfur.

• Survey engineers developed a proprietary process for producing high-surface-area hydrated limes for use as sorbents for sulfate emissions. Pilot-scale tests performed by several commercial firms and institutions, including the Consolidation Coal Company, KVB Inc., and U.S. EPA, exhibited superior performance for the hydrate developed by the Illinois State Geological Survey compared with the commercially available calcium hydroxide sorbents. The results indicate that the Survey's hydrate is the most effective sorbent tested to date for controlling sulfate emissions from coal-fired combustors.

Oil and Gas

• On June 29, the U.S. Department of Energy (DOE) awarded the Survey a grant to undertake research on economically viable strategies to improve the recovery of oil from existing fields in Illinois. The grant, which is being matched by the State of Illinois, covers the first 12 months of a 4-year program. Initial matching State funds were used to purchase a VAX Geologic Workstation and a Zycor mapping package. These have already been used in mapping the distribution and orientation of Cypress sandstone bodies in southern Illinois and in modeling shapes of bounding surfaces that control the distribution of select oil and gas fields.

• The Illinois State Geological Survey, one of 15 charter members of the Geoscience Institute for Oil and Gas Recovery Research (which has grown to include 23 institutions), helped develop a prioritized research plan for improved oil recovery from existing fields. The document was submitted to the U.S. Department of Energy for review and use in planning future research. A joint Illinois, Indiana, and Kentucky proposal, "Mobile Oil Recovery Efficiency in Contrasting Geologic Settings," was developed and submitted to DOE through the Geoscience Institute. The proposal—a landmark in cooperative research between the three states—was submitted as part of the newly formed Illinois Basin Consortium, which comprises the three State Surveys.

• Rock and fluid properties were compiled by oil and gas reservoir and by field in Illinois. These data indicate that the McClosky producing section may be divided into three distinct groups of reservoir behavior. The Aux Vases and Cypress Sandstones can be divided into two groups.

• Reservoir quality of Cypress Sandstone is largely dependent on the deltaic facies in which it was deposited. Four distinct facies can be recognized from electric log characteristics.

• An understanding of oil production problems in Cypress and Aux Vases reservoirs developed from detailed thin-section SEM/EDS, and X-ray diffraction (XRD) analyses of samples from these units coupled with core and electric log characteristics. Heterogeneities were noted that must be considered in well spacing and completion and stimulation practices.

• Gravity surveys were used for locating Silurian reefs that are potentially hydrocarbon-bearing. An example of the Marine Field in Madison County, Illinois, illustrates how measurement of the local gravity field can aid in this type of exploration. This study indicates that similar mapping techniques could be effective in locating buried Silurian reefs elsewhere in the Illinois Basin.

• A preliminary study shows that Lower Devonian oil fields in southwestern Illinois are controlled by a regional pinchout of porous dolomite.

• Gas chromatography has been used to correlate crude oils with source rocks in the Illinois Basin. Analysis of crude oils shows fingerprint patterns indicating that Illinois crude oils have at least two distinct sources, the New Albany shale and an unidentified Ordovician stratum.

• The CONQUeST well data management system is operational for oil and gas permits, workovers, mail, historical (pre-1915) well information, completion reports, water well permits, and well records through prototype programs now in production use within the Geological Records Unit.

Groundwater Resources

• Several groundwater resource studies were undertaken to provide information on locations of potential water supplies: an assessment of the northern 35 counties in Illinois; a statewide study to define buried valleys in the bedrock surface and whether the valley-fill deposits may provide groundwater resources; exploration for groundwater resources in Kane County; and ongoing studies for several municipalities, including St. Charles, Normal, and Bloomington.

• Contour maps and cross sections illustrating depths to groundwater with concentrations of up to 10,000 mg/L were produced for Clay, Crawford, Lawrence, and Wabash Counties.

• The Illinois State Geological and Water Surveys are providing technical assistance to the staffs of county Soil and Water Conservation Districts (SWCD) in assessing the potential impacts of large-capacity water wells on the groundwater resources of areas around the wells. Survey staff evaluated 90 well sites to determine the hydrogeologic conditions in the surrounding area and also completed two regional reports for Kankakee County. They also provided technical assistance to the SWCDs of Kankakee, Iroquois, McLean, and Tazewell Counties to help resolve 116 complaints regarding the loss of water supply to wells in the vicinity of large-capacity water wells.

• Electrical resistivity surveys were conducted to locate or define potential aquifers at 6 municipal, 1 subdivision, 31 privately owned, and 14 farm sites. Also, 57 borehole logs were run in 10 counties to provide subsurface information on aquifer locations and geologic conditions.

• Survey scientists responded to more than 1,500 phone calls and provided 171 reports, and 90 letter responses to well drillers, farmers, citizens, industries, and government agencies requesting information on the location, development, use, and evaluation of groundwater resources.

• An automated database on groundwater was organized and developed using well records and other subsurface information on file at the Survey. The staff is working with the Illinois State Water Survey and the U.S. Geological Survey to develop a coordinated, compatible groundwater database for all potential users.

Industrial and Metallic Minerals

• The Paducah Conterminous U.S. Mineral Assessment Program (CUSMAP) was designed to evaluate the mineral resource potential of southernmost Illinois and neighboring areas of Missouri, Kentucky, and Indiana; a surficial geological map for the quadrangle is nearly complete. Bedrock maps, cross sections, stratigraphic columns, and text covering stratigraphy, structural geology, and economic geology were prepared for each of the four 1:100,000 quadrants that make up the Paducah quadrangle.

• Maps of Cambrian and Ordovician carbonates were completed, as well as four cross sections depicting vertical and lateral changes in the Valmeyran (Middle Mississippian) limestones in Illinois. This work was part of a cooperative project with the U.S. Geological Survey and ten other states on Midcontinent strategic and critical numerals.

• A computer database on 357 underground mines was completed under contract with the Illinois Mine Subsidence Insurance Fund.

• Geology and ore deposits of the fluorspar district were reported as part of a guidebook for the 28th International Geologic Congress.

Mineral Economics

• Strategic and critical minerals were analyzed and defined, primarily in terms of supply vulnerability. From this work, results indicate that only about ten strategic and critical minerals warrant being stockpiled.

• Three flow diagrams were designed to show alternative methods for the recovery of fine coal currently being discarded by coal-cleaning plants. An estimated 6 to 8 million tons of fine material containing an average of 50-percent coal is deposited annually in slurry ponds in Illinois. The flow diagrams should assist operators in determining for their own plants the economic feasibility of recovering fine coal.

• The Directory of Mineral Producers in Illinois was thoroughly revised and reflects the industry much more accurately than before.

ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY

Environmental Studies and Assessment

• The major 2-year geotechnical site investigation for Argonne National Laboratory's 7-GeV Advanced Photon Source was successfully concluded with the submittal to Argonne of a 331-page final report on the stratigraphy, sedimentology, hydrogeology, and engineering geology of the site. The report concludes that there are no problems that would preclude construction and successful operation of this facility so long as normal engineering precautions are taken. The effort provided a sound basis for the engineering design study and helped ensure that the facility will be constructed to meet the stringent vibration requirements.

• A redirected and refocused wrap-up of the Superconducting Super Collider (SSC) program incorporated the information garnered in the SSC effort in reports and in the Survey's database for use in other projects in the region. A geology-for-planning project for Kane County is already applying the information to (1) locate materials capable for land application of waste water, (2) locate possible reservoir sites, (3) identify sites suitable for solid waste disposal, and (4) update and reevaluate aggregate and dolomite resources.

• The Survey implemented a contract with the Illinois Department of Transportation (IDOT) to develop procedures and methods for preliminary site assessments. All IDOT property will be investigated for the potential of containing natural or manmade geologic hazards.

Geology for Planning

• In the first phase of a projected geology-for-planning study, the Survey is providing information and assistance to Champaign County, which is investigating sites for a landfill. A database of 3,237 drilling logs was reviewed, and key logs were selected to construct six east-west cross sections and eight slice maps to a depth of 75 feet to depict the geology and location of aquifers and other features that must be considered in landfill siting.

Lake Michigan Coast and Basin Studies

• Detailed information was obtained on bottom morphology, shore development, and erosion rates in Lake Michigan coastal areas from wide-ranging studies that included bathymetric mapping, sonar surveys, littoral drift investigations, compilations of shore erosion histories, and lake level and sedimentation histories—efforts jointly conducted by the Illinois State and U.S. Geological Surveys. Under lease to the U.S. Geological Survey, researchers on the R.V. Neptune measured bathymetry, conducted shallow geophysical soundings, took sidescan sonar images, and collected sediment samples along five transects in Illinois.

• Through a grant from the U.S. Geological Survey and in cooperation with them, a sidescan sonar survey was completed along the entire Chicago lakefront. This work complements the preliminary survey carried out over a portion of the lakefront in 1987. The surveys are useful in documenting the nature of the damaged shoreline protection structures and in helping to identify the processes responsible for the damage.

• Sidescan sonar imaging also covered the shoal area, known as the Indiana shoals, on the Lake Michigan extension of the Illinois-Indiana line and identified major commercial sand deposits.

• The recent history of the Illinois shore of Lake Michigan and an inventory of all properties along the Illinois shoreline are being documented in a series of aerial photographs, digitized maps, and a revised coastal atlas. A draft of the atlas was distributed to select government agencies and municipal authorities for review. Also, computer-generated maps of the Illinois shoreline for the periods 1872 and 1988 were provided to U.S. Geological Survey-National Oceanic and Atmospheric Administration (NOAA) researchers, who are determining average recession rates of the five Great Lakes.

• Using maps of sediment impounded by the earliest jetties built at the Chicago River mouth, researchers computed littoral drift rates from the early 1800s. These rates will be used as benchmarks for comparison with modern-day rates.

• One-foot-interval contour maps were generated from a 1988 lake-bottom topographic survey. These maps will serve as baseline data to study the future impacts of the installation of North Point Marina on beach and lake-bottom erosion and deposition.

• Survey geochemists compared the average concentrations of eight metals of environmental interest among sediment samples from various locations in or adjacent to Lake Michigan. Included in the comparison were samples from Lake Calumet, Calumet Harbor, Little Calumet River, Lake Michigan, and Wolf Lake. The results showed that Waukegan Harbor sediments contain approximately 1.5 times more cadmium and chromium, 13 times more sodium, and excluding the Cal-Sag Channel, 1.5 times more zinc than other nearby water systems. Fish from Waukegan harbor and surrounding areas tested higher than fish collected from Lake Superior waters in lead (28 times), zinc (3 times), chromium (37 times), and copper (3 times), but contained an order of magnitude less mercury and 40 percent less cadmium.

• PCB concentrations in fish from Indiana Harbor ranged from 15 ppm to 7,900 ppb. The concentrations are generally higher than in Waukegan Harbor fish. Indiana Harbor sediments were also found to contain higher quantities of cadmium (6 times), chromium (6 times), zinc (6 times), iron (3 times), nickel (3 times), and lead (2 times) as any other nearby water system excluding the Cal-Sag Channel. Concentrations of metals and organics decreased toward the mouth of the harbor, but researchers have not determined whether contaminated sediments were carried into the lake from the harbor.

Rivers, Backwater Lakes, and Wetlands Research

• Using a cesium-137 dating technique, the Illinois State Geological Survey in cooperation with the Water Survey determined sedimentation rates in the lower Cache River wetlands area ranging from 0.3 to 2.8 cm of sediment per year since the 1950s. The patterns of sedimentation will help guide conservation efforts to preserve these unique wetlands.

• A mathematical groundwater flow model was developed for a portion of the Des Plaines River Wetlands Demonstration Site. This model predicts that water loss from wetlands ponds to the groundwater will not be significant compared with the capacity of the site's pumps.

Hydrogeologic Investigations

• In compliance with the Illinois Groundwater Protection Act, a map showing recharge areas in the state was compiled and submitted to the Illinois Environmental Protection Agency (IEPA) and the Interagency Coordinating Committee on Groundwater. Recharge areas are ranked according to the

relative potential of geologic materials to transmit water, the location and importance of aquifers as suppliers of groundwater, and soil infiltration rates. This information will be combined with data supplied by the Illinois State Water Survey on the distribution of potential sources of contamination. The IEPA and Surveys will use these data to identify areas with extremely high potential for groundwater contamination and to set up groundwater planning regions on a priority basis.

• Modeling of geological scenarios common to Illinois indicates that it is possible to quantitatively rank them for their potential for groundwater contamination from migration of landfill leachate. The regionally mapped scenarios suggest that stratigraphic conditions over roughly 50 percent of the state are favorable to meet the suggested Pollution Control Board (PCB) compliance distance of 100 feet or less for migration of contaminants from landfills over a 100-year period.

• The Hydrogeology Research Laboratory was formed on December 1, 1988, to focus research efforts on groundwater pollution and protection with an emphasis on the movement of fluids and chemicals in very low permeability shales and glacial tills. The experiments with a field-scale clay liner are recognized as a part of this effort. Data indicate that the hydraulic conductivity of the experimental liner is 4×10^{-8} cm/sec, significantly lower than the EPA maximum prescribed limit of 1×10^{-7} cm/sec.

• Illinois State Geological Survey/Water Survey Cooperative Report 11, recommending a statewide survey of agricultural chemicals in rural private wells, was released in May 1989. A pilot study to develop the methodology for the survey was initiated in five representative township-size areas.

• Monitoring of the persistence and mobility of pesticides in four loessial soils indicated that the greatest mass of pesticide residues was retained in the upper 20 centimeters of the soils and that trace levels were detected below 20 centimeters in the spring of the year following application. Leaching depends on soil type, and differences in the depths of leaching of two pesticides apparently resulted from variations in their relative persistence.

Waste Management

• The Illinois State Geological Survey continued to provide support to the Illinois Department of Nuclear Safety (DNS) and their primary subcontractor, Battelle Memorial Institute, for site characterization efforts for a low-level radioactive waste disposal facility in Clark or Wayne Counties. Elements to adequately characterize the candidate sites were developed in a collaborative effort between Battelle and the Survey.

• Two reports, issued in final form in January 1989, summarize siting criteria and geologic considerations for siting a low-level radioactive waste facility and present recommended methodology for site selection that includes (1) regional screening, (2) area screening, and (3) site characterization.

• The Survey in cooperation with the Department of Energy and Natural Resources's Office of Solid Waste and Renewable Resources met with Champaign, Crawford, and Madison County officials to assist in the design of a screening approach to siting landfills.

• Technical assistance is being provided to McHenry and Champaign Counties in locating geologically suitable sites for landfills.

• Waste management activities were extended to study the disposal or re-use of the waste solids from fine-coal cleaning processes and to aid in providing information useful in guiding the disposal of oil field brines by underground injection.

• In ongoing research work at the Wilsonville waste disposal site, monitoring data reflect the effectiveness of the clean-up and the processes of contaminant transport in the subsurface over the past 2 years. The effect of waste excavation is obvious for the most mobile compounds, but is not detectable in groundwater samples for the least mobile. Biodegradation modeling indicates rates of degradation for aromatic hydrocarbons that correspond to half-lives between 35.7 and 192.5 weeks.

• An award-winning Survey paper, published in the fall 1988 issue of the Ground Water Monitoring Review, showed that groundwater samples collected from slowly recovering wells after evacuation had no significant differences in volatile chemicals at any time up to 48 hours, but that concentrations before evacuation were significantly lower than after evacuation.

• Survey staff provided 111 telephone responses, 15 preliminary reports of hydrogeological investigations, 76 letter reports, and conducted 27 office visits to answer queries from consultants, citizens, industries, and governmental agencies regarding potential and existing sites for landfills and groundwater monitoring.

Earth Hazards and Geotechnical Studies

• Longwall mining technology is expanding in Illinois' coal districts. The Illinois Mine Subsidence Research Program, established in 1985, continued to provide information on the events and processes involved in planned mine subsidence and its impacts. This documentation is a major step in meeting the program's goal to develop guidelines for underground mining for maximizing coal extraction while preserving the productivity of farmland in Illinois. Information gathered to date while monitoring water tables during and after subsidence indicated that the aquifer is restored approximately 3 months after mining. Knowledge of the origin of fractures and an understanding of their distribution is rapidly increasing. Preliminary results on current subsidence mitigation practices and their impact on 1988 crop yields indicated no significant difference in yields between control and mitigated sites for corn and soybeans.

• Survey staff continued to provide guidance and technical assistance on two natural geologic hazards: radon and landslides. At Chester, Illinois, excess water was identified as the cause of unstable slopes. Chemical analyses of water associated with the landslide showed high concentrations of chloride and fluoride, revealing that the water source was probably a broken water line.

• A seismicity study of Illinois establishes the New Madrid Seismic Zone in Missouri as the greatest source of seismic risk in Illinois, particularly the southern portion.

GENERAL AND BASIC RESEARCH

Crustal Studies

• A Consortium for Continental Reflection Profiling (COCORP) seismic line across Illinois shows seismic reflections indicating layering in upper crustal rocks of Pre-Cambrian (Proterozoic ?) age beneath the Illinois Basin and showing interfaces also from the upper mantle. New insights are evolving on the origin and development of the Illinois Basin.

• The Survey is working with the U.S. Geological Survey to pick the best location(s) for new Illinois seismometer stations.

Basin Analysis

• Initial results of quantitative modeling of basin subsidence using deep well data indicate that tectonic subsidence was controlled by three mechanisms: rifting, thermal subsidence, and an isostatically uncompensated mass in the lower crust.

• To advance their programs of research in basin analysis, the Illinois, Indiana, and Kentucky Geological Surveys formed the Illinois Basin Consortium. The Consortium will address geoscience problems and issues of a basinwide nature through cooperative, integrated, multidisciplinary effort.

• Plans were developed for a grid of 20 regional cross sections to cover the Illinois Basin, providing a framework that should significantly enhance understanding of its evolution and of the controls on hydrocarbon migration and entrapment and on mineralization. Logs of approximately 120 wells for the 20 sections were digitized, and a preliminary section was developed for display. Input on the cross-section program is being provided by the Illinois, Indiana, and Kentucky Geological Surveys.

• Framework studies for specific stratigraphic intervals are also underway. For example, 106 Silurian cores, totaling 45,000 feet, from holes drilled in southern Cook County were logged. Litho- and biostratigraphic correlations of this material will provide a framework for the analysis of aggregate resources in the area. Results of the logging have already led to discovery of Devonian-aged rocks at the bedrock surface along the Indiana border, descriptions of reef/interreef strata, and refinement of the Silurian stratigraphy for this part of Illinois.

• An updated conodont biostratigraphy was formulated that provides greater accuracy in correlating Upper Devonian rock units throughout the Illinois Basin.

• The Tri-State Committee on Correlations in the Pennsylvanian System agreed on a proposed classification that divides the Pennsylvanian strata into Groups and Formations, thus enabling a common nomenclature to be applied to these strata throughout the Illinois Basin.

• Detailed facies analyses indicate that paleostructure and topography, reflected in present-day structure of the top of the Trenton (Galena) surface, controlled subsequent thickness and distribution of Maquoketa carbonates on structural highs and shales in structural lows.

• Bedform geometry, sedimentary structures, and detailed paleontology of the Caseyville and lower Tradewater Formations in southern Illinois provide ample evidence of brackish to marine dominated depositional systems in this area during early Pennsylvanian time.

• Rock failures caused by present-day regional tectonic stress were described in a paper for the Energy Minerals Division of the American Association of Petroleum Geologists. Recommendations state that to minimize stress-related rock failure, mine openings should be oriented 45 degrees to the major stress axis.

Geologic Mapping

• Significant mapping progress was made on several 7.5-minute geologic quadrangles as a part of the Cooperative Geologic Mapping Program (COGEOMAP) effort with the U.S. Geological Survey. Cartographic work by Northern Illinois University is in the final stages for the Creal Springs, Eddyville, and Stonefort quads. Field mapping has been completed for five other COGEOMAP quads and the resulting maps are in various stages of completion. Field mapping was underway for three additional quads during the reporting period.

Quaternary Investigations

• The Quaternary Framework Studies Section was established effective December 1, 1988, as a part of the Survey's reorganization. The section is developing a research program to establish the three-dimensional framework of glacial deposits and other surficial materials that overlie bedrock throughout the state. An understanding of the processes that resulted in these deposits is essential to the development of this framework, to the expansion of our knowledge of their hydrogeologic, geotechnical, and geological properties, and to predictions of the geologic capacity of our surroundings to sustain and encourage wise economic development.

• A catalog of key stratigraphic control points for the Quaternary was initiated in a pilot study in northern Illinois. The quality of this database is established through a rating system indicating the adequacy of control.

• Classic glacigenic sections in northeastern Illinois are being reexamined to identify major lithofacies associations, glacigenic sequences, and their geometries. Increased knowledge of these parameters makes it easier to predict subsurface relationships that bear on groundwater resources, land-use planning, landfill siting, and engineering properties for construction.

Paleontology/Palynology Investigations

• These investigations continue to contribute information useful in age dating and correlating rock units and in interpreting their depositional environments. For example, on the basis of conodonts,

researchers have shown that the recent discoveries of gas in the Michigan Basin are, in part, coeval with the Everton Dolomite and St. Peter Sandstone, rather than with the older Prairie du Chien rocks. Industry attention is now focused on these and older rock units in Illinois.

• The Mississippian conodont genus *Lochriea* was redefined, making it more useful as a biostratigraphic indicator.

• Benthic foraminifera found in the Paleocene Upper Clayton Formation in southernmost Illinois indicate that this unit was deposited under open marine conditions in water depths of less than 20 meters.

• Participation in a Midcontinent working group and an international commission is helping to focus interest on Illinois' Pennsylvanian stratigraphy. The comparative data provided advances our knowledge of ages and paleoenvironment of these strata and how they correlate with significant geological events.

• Paleontological and palynological services continue to provide researchers at the Illinois State Geological Survey and elsewhere with valuable information for use in establishing correlations for stratigraphic framework.

Geochemistry

• Stable isotope and radiocarbon analyses of gas samples from monitoring wells around a landfill in Du Page County indicated that the gas had originated from the landfill.

• Work with the Brookhaven National Laboratories' synchrotron X-ray fluorescence microprobe has demonstrated its capability to measure trace elements in areas of about 20 by 20 µm. Microprobe analyses showed that pyrite in Illinois coal is enriched in arsenic, selenium, lead, and thallium.

Mineralogic Investigations

• The Clay Mineral Laboratory continued to support a broad range of projects for Survey staff and others in Illinois seeking information. For example, the laboratory identified materials stored at an abandoned hazardous waste site in Chicago as harmless.

Computer Research

• Rapid advances continued in programming and in developing personal computer (PC) software at the Survey. For example, the Geological Records Unit, which has been entering oil and gas well data on a PC-based computer system, can now transfer these data to the Prime 9955 and to the main well data files through programs and procedures that were recently written and made available. This interface provides access for users of the main well data files to the most current permit data.

• New computer programs allow easier access to the Illinois Department of Energy and Natural Resources Geographic Information System (GIS). These programs also permit faster map and cross-section construction, and listing of operators who do not comply in submitting logs and well records.

• A network was designed to link all computer resources in the Survey, using an Ethernet backbone and telecommunication's B-jacks in every office. When implemented, the network will allow file transfer between computers, remote log-in to computers throughout the Survey, shared use of special peripheral devices, and access to campus computing resources via the University of Illinois Protean optical-fiber network.

• A SUN 3/60 workstation was acquired.

• Computer-generated maps were developed to help the Southwestern Illinois Metropolitan and Regional Planning Commission select possible sites for establishing a brick-manufacturing facility in that part of the State.

Scientific Support Services

• A quality assurance-quality control plan was developed and approved for laboratory and field procedures and is now being implemented through the development of written "Standard Operating Procedures" for each routine procedure that either produces quantitative data or leads to its production.

• With new equipment purchased under the Build Illinois Program, the Survey's Isotopic Analysis Service Laboratory has expanded the analytical capabilities to include analyses the five major stable isotopes (C, N, O, H, and S).

• The Isotope Geochemistry Laboratory and the Radiocarbon Dating Laboratory undertook 1,373 stable isotope determinations and 169 radiocarbon age determinations, respectively.

• The Coal Analysis Laboratory acquired two new instruments, a LECO CL35 chlorine analyzer dedicated to coal analyses and a Microtrac II particle-size analyzer. The laboratory analyzed more than 1,500 samples of coal and coal-related products involving more than 7,000 analyses.

Database Enhancement

• The Pending File Task Force (PFTF) in the Geological Records Unit completed the processing of a backlog of 6,700 oil well records, 4 months ahead of the targeted December 1988 date. As of December 1, 1988, the PFTF had processed 9,934 completed well records, 3,264 more than projected. Processing of oil well records is now current for the first time in several years.

• Efforts of the Geological Records Unit were redirected as of November 1, 1988, to form a Water Well Records Task Force. The objective is to sort, organize, and enter into the Survey's computer database some 27,300 water well records. At the end of the report period, 12,486 records had been processed into the system.

• An automated groundwater database was developed and organized, using water well records and other subsurface information on file at the Survey.

TECHNICAL AND ADMINISTRATIVE SERVICES

• The Business and Financial Services Unit, Grants and Contract Office, Human Resource Office, and Word Processing Center managed heavy loads created by the increased numbers of grants and contracts.

• The Technical and Administrative Branch Office dealt adeptly with the reorganization of the Survey, handling the telecommunication changes along with its other services and responsibilities.

• The Business and Financial Services Unit implemented a comprehensive internal contract and accounting system, increased and improved internal data reporting and analysis to staff, streamlined purchasing for research projects, initiated electronic transfer of the Survey's payroll warrants directly from the Comptroller's Office, and helped formulate and gain approval for implementing a general services concept for appropriately funding required administrative and technical staff through sponsored research projects.

• The Grants and Contracts Office implemented a new system for the recovery of reasonable and allocable direct expenditures associated with general services rendered in support of sponsored research activities at the Survey.

• The Human Resource Office handled a 55-percent increase in the number of searches for personnel (largely for grants and contracts), processed 15 new state appointments and 48 new contract personnel, 96 transfers of contract personnel, 63 extensions of contract personnel, and 2,916 acknowledgment letters in addition to work related to retirements, resignations, and terminations of staff with accompanying exit interviews. In addition to the various normal daily activities, major

efforts were devoted to administering and processing benefits, to training staff, and revising job descriptions.

• The Library/Map Room and Public Information were reorganized and combined into one unit. The Library/Map Room essentially completed archiving the massive Superconducting Super Collider files.

• Valuable services were provided to the public through the Information Office, which handles general inquiries and over-the-counter sales of Illinois State Geological Survey maps and publications, and through the Earth Science Information Center, which sells quadrangle maps and other U.S. Geological Survey products.

• Major new equipment, including a duplicator and a binder, was installed in the Duplicating Service Shop.

• The Public Liaison Office added government relations to its responsibilities and extended its activities to include city, county, and regional planners, engineers, zoning officials, and legislators and their staffs. Grass roots visits were undertaken to familiarize officials, community leaders, and the media with the activities of the Survey. A new mini-annual report was developed and circulated last year highlighting the Survey's past, present, and future activities. The role of the Survey's Public Liaison Office expanded considerably.

• The Publications, Graphics, and Photography Unit expanded into computer graphics in 1988-89. By midyear, the Computer Research and Service Section and Publications had linked the Unit's graphics system to the Illinois Geographic Information System through the Prime computer.

• For Survey scientists and the Public Liaison, the Publications Unit prepared 22 posters, including the 44-foot display for the International Geological Congress held in Washington D.C. in July 1989. The display, "ISGS Maps the Future of Illinois," was presented by the head of Educational Extension, the Public Liaison, and the Chief. The Publications Unit also provided the public with information through a steady output of scientific reports, educational booklets, fliers, and the *ISGS Geonews*.

• The Technical Design, Operation, and Maintenance Unit provided vital support to all Survey staff ranging from construction of research equipment of all types to repair work, equipment maintenance, and moving of offices. A total of 315 work orders were completed, an increase of 78 over work orders generated for FY88. In addition, 158 internal work orders for electronic repairs, maintenance, and installations were processed, an increase of 58 requests over the previous reporting period.

• The Educational Extension Unit provided four field trips to the public at Forrest, Wolf Lake, Newton, and Savanna. For each field trip, participants received guidebooks that described the geology of the area in detail. A total of 471 people attended these trips, including 133 elementary, high school, and college students, 68 teachers, and 250 other persons.

• A major contribution to the groundwater education effort in Illinois was produced, a slide-audiotape lecture called "Groundwater—Protecting Our Invaluable Hidden Resources." This show introduces adult audiences and high-school students to the basic concepts of groundwater geology, and discusses how groundwater becomes contaminated and what individuals can do to protect it.

• The Geological Samples Library acquired a new Raytech Model CS18a core saw, which enhances the capabilities of the library and the value of slabbed cores for research purposes.

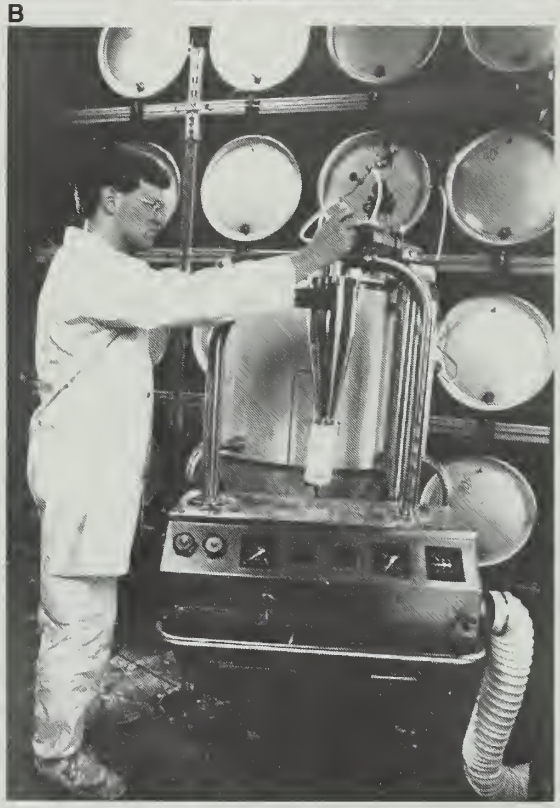
• Three Capital Development Board (CDB) projects to upgrade facilities are underway. Included in these projects is the renovation of 20 laboratories in two Geological Survey buildings. Some of the major work involves installing shower drench stations, improving ventilation systems, installing fume hoods, renovating plumbing and waste systems, an electrical upgrade, removing asbestos, and putting in a make-up air system. A fire/smoke alarm system is being installed in the Natural Resources Building, which houses the Illinois State Geological Survey.

Mineral Resources Research and Service

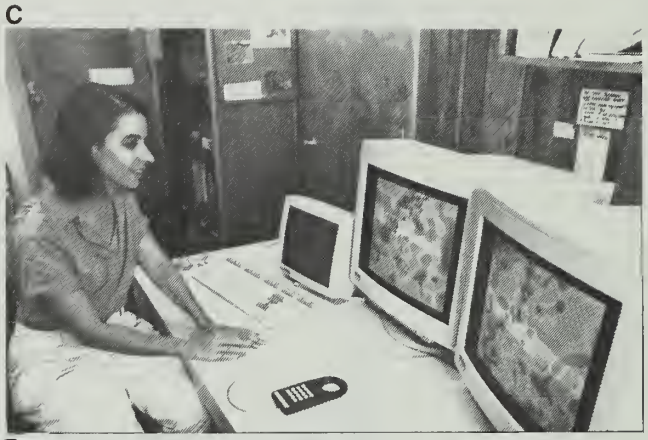
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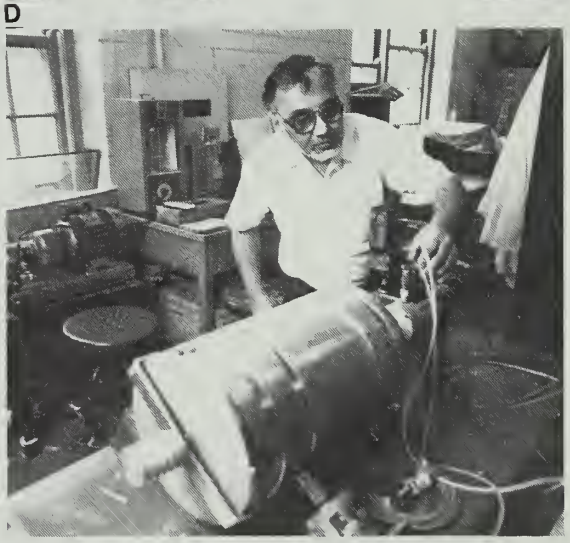
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(A) Donald Oltz, head of the Oil and Gas Section, demonstrates a core test system being used for studies of the geological characteristics of oil-bearing reservoir rock. Studies are aimed at improving well completion technology. (B) David Moran, chemical engineer in the Minerals Engineering Section, monitors a spray dryer used to produce a high-surface-area hydrated lime that efficiently removes sulfur dioxide from coal. (C) Beverly Seyler, geologist in the Oil and Gas Section, adds color to computer-generated subsurface geology maps of oil-producing sandstones in Edwards County. Her study is part of a new program to improve oil recovery from Illinois wells. (D) Minerals engineer Latif Khan, Industrial Minerals and Metals Section, adjusts a meter on the computerized grinding mill he designed to investigate ways of improving grinding processes.

ILLINOIS MINERAL INDUSTRY IN 1987 AND 1988

The mineral extraction industries generally continued their downward trend in 1988, except for the industrial minerals industries, specifically sand and gravel and stone (figure 1). The decline in value was attributible to a 6.9-percent drop in coal production, a 6.7-percent drop in oil production, and a 15-percent drop in oil prices. Stone production rose by 4 percent, and sand and gravel production by 8 percent, while prices for these minerals remained nearly unchanged. The total value of extracted minerals in 1988 was about $2.4 billion, down 8.5 percent from 1988. The overall inflation rate was about 4.5 percent, and the decline in value in real terms in 1988 was about 13 percent (table 1).

The Illinois mineral industry has not fared well in the 1980s. The Illinois Gross State Product (GSP) in constant 1982 dollars increased by 15 percent between 1979 and 1988 (figure 2), despite the 1982 recession. By contrast, the value of minerals mined, processed, and manufactured consistently declined during the same time period. The 1988 value was 40 percent below the 1979 value. Although oil price declines contributed to the problem, real losses occurred in all segments of the industry.

Factors such as clean air regulations, oil prices, and interest rates contributed to the recent decline in Illinois mineral industries. Coal desulfurization, declining oil reserves, and the cost of mining and using Illinois coal are factors being addressed in an attempt to reverse these trends.

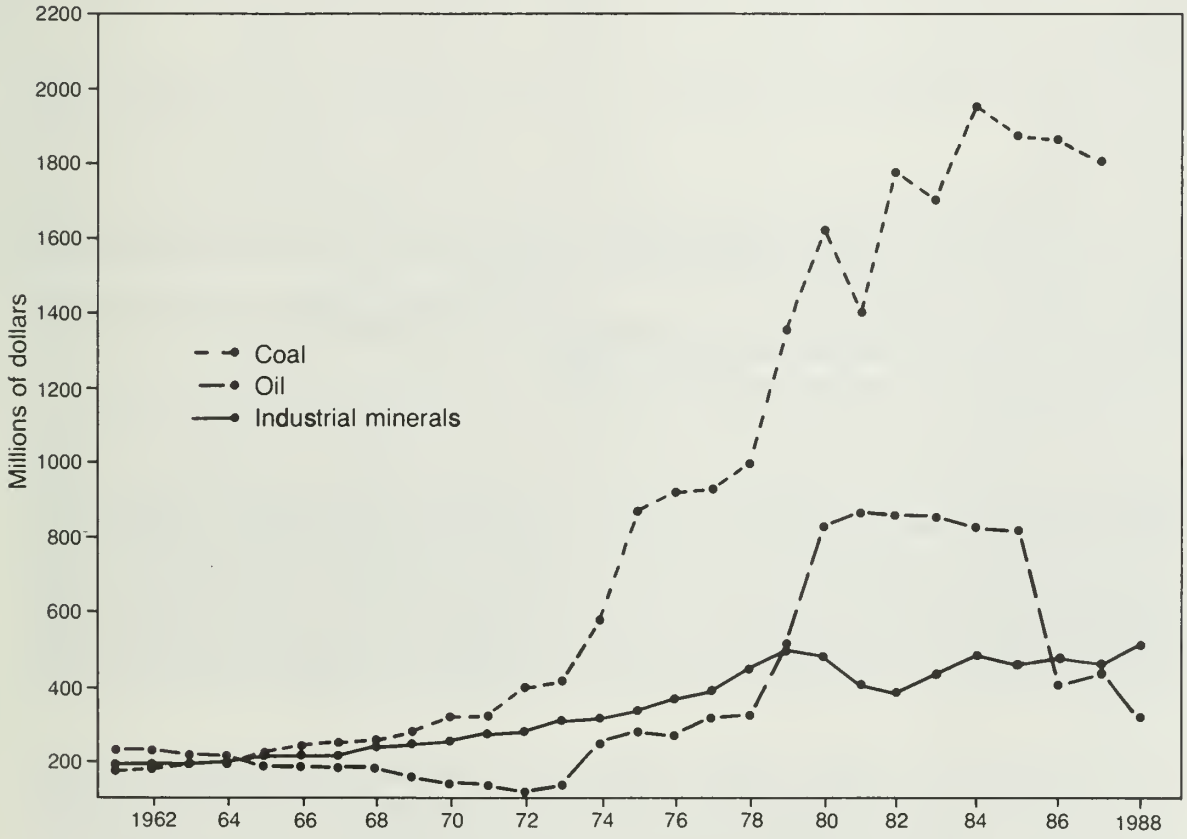


Figure 1 Value of Illinois minerals and fuels.

Table 1 Mineral production data for 1987 compared to preliminary data for 1988

Minerals extracted	Unit	1987 Quantity	1987 Value (1000 $)	1988 Quantity	1988 Value (1000 $)	Percentage of change from 1987 to 1988 Quantity	Percentage of change from 1987 to 1988 Value
Fuels							
Coal	thousand tons	60,761	1,796,106	56,576	1,640,712[b]	- 6.9	- 8.7
Crude oil	thousand bbl	24,096	421,685	22,476[b]	332,420[b]	- 6.7	- 21.2
Natural gas	thousand Mcf	1,371	3,071	1,340[b]	2,935[b]	- 2.3	- 4.4
Industrial and construction materials							
Stone[c]	thousand tons	52,102	216,212	54,300	224,900	+ 4.2	+ 4.0
Sand and gravel	thousand tons	32,646	138,847	35,250	153,600	+ 8.0	+ 10.6
Clay[d]	thousand tons	233	977	236	1,076	+ 1.3	+ 10.1
Fluorspar	thousand tons	W	W	W	W	- 2.4	- 2.4
Tripoli	thousand tons	W	W	W	W	+ 4.0	- 11.5
Metals							
Lead	tons	W	W	W	W	- 70.9	- 70.4
Zinc	tons	W	W	W	W	- 21.8	+ 88.1
Silver	troy ounce	W	W	--	--	--	--
Copper	tons	W	W	--	--	+ 38.5	+100.0
Other							
Peat	thousand tons	W	W	W	W	- 20.7	- 28.2
Gem stones		NA	15	--	15	--	--
Barite, primary	thousand tons	W	W	W	W	--	--
Values that cannot be disclosed (W)		--	43,229	--	42,043		- 2.7
Total value of minerals extracted			$2,620,142		$2,397,701		- 8.5

[a] source: U.S. Bureau of Mines and Illinois Department of Mines and Minerals
[b] estimated by Illinois State Geological Survey
[c] dimension stone included with values that cannot be disclosed as 1987 must be concealed.
[d] excludes fuller's earth; included with values that cannot be disclosed.
W = withheld to avoid disclosing individual company confidential data.

As part of a renewed effort to reverse the downward trend in the Illinois mineral industries, the Illinois State Geological Survey recently initiated a 4-year project, "Improved and Enhanced Oil Recovery Through Reservoir Characterization." The goal of the project is to extract some of the 1.5 billion barrels of mobile bypassed oil in Illinois. Studies are underway to characterize Illinois reservoirs, define the geologic heterogeneities within reservoirs that cause oil to be bypassed, and identify methods to increase recovery of the oil still remaining in the reservoirs. Independent operators in Illinois will be kept informed about technologies developed in the course of the research.

Another Survey project is focused on the production of a hydrated lime that can very efficiently remove SO_2 from coal-fired boiler gases, thereby reducing the cost of Illinois coal by producing less sludge for disposal. Research continues on locating additional sources of construction aggregates for the metropolitan Chicago area, where the depletion of known resources and urban encroachment on undeveloped sites have raised concern about the future of the aggregate industry.

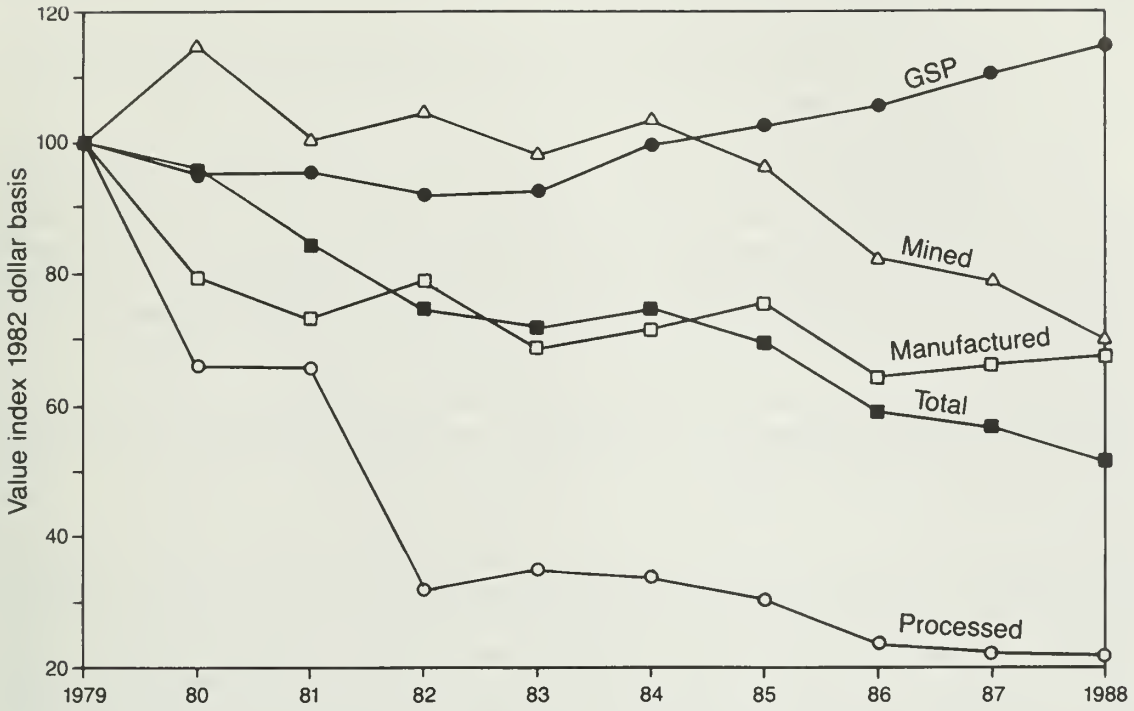


Figure 2 Value of Illinois Gross State Product and the minerals mined, processed, and manufactured in Illinois 1979-88 in constant 1982 dollars.

These and other Survey projects that contribute to the economic prospects of Illinois minerals industries are reviewed in the Mineral Resources and Engineering section of this report.

Activities Affecting Illinois' Mineral Industries
Significant mineral resource events occurred during the year.

• Longwall mining technology expanded in Illinois coal districts. Installation of longwall faces in Freeman United Coal Corporation's Orient No. 6 Mine and Kerr McGee's Galatia Mine brought the number of longwalls in Illinois to nine. Other companies are also contemplating a move to longwall mining, which permits higher extraction rates, provides safer working conditions for workers, lowers costs, and allows subsidence events to be predicted and controlled. The Illinois Mine Subsidence Research Project supported jointly by the Illinois State Geological Survey and the U.S. Bureau of Mines is making a significant research contribution to the understanding of mine subsidence. The increased productivity coupled with predictable and controlled subsidence of longwall mining accounts for the current trend toward longwall mining. The shift to longwall mining will be a stabilizing factor as the Illinois coal industry faces the prospect of new and costly SO_2 restrictions.

• President Bush proposed controls on SO_2 and NO_x emissions from coal-burning facilities that will seriously affect Illinois coal industry. Currently, only about 27 percent of Illinois coal sold in and outside the state is scrubbed. Illinois coal having an average sulfur of content of about 2.7 percent emits about 5 pounds of SO_2 per million Btu. The new standards would require a reduction in SO_2 emissions to 2.5 pounds per million Btu by the year 1996 and to 1.2 pounds by 2000. More than 70 percent of Illinois coal would be affected.

• McHenry Sand and Gravel Company of McHenry, Illinois, one of the larger aggregate producers in the important sand-and-gravel-producing area of eastern McHenry County, was purchased by Meyer Materials of Des Plaines, Cook County, Illinois.

• The Ozark Mahoning Company acquired the Minerva No. 1 Mine in the Illinois fluorspar district from Inverness Mining Company and began dewatering the mine to restart production.

• An extremely efficient hydrated lime SO_2 absorbent was developed at the Survey's Applied Laboratory. If scale-up studies are successful this process may help Illinois utility companies meet the proposed regulations. This and other desulfurization research at the Survey represent major efforts to keep Illinois coal competitive. Survey scientists involved in the coal characterization program are using the scanning electron microscope to determine concentrations and variations of organic sulfur in individual carbonaceous components of coal; basic knowledge gained from this research can be useful in the design of more efficient processes to remove sulfur from coal.

• Nuclear energy surpassed coal as the prime fuel for electricity generation in Illinois during 1988. About 56 percent of Illinois' electric power in 1988 was generated by nuclear plants and about 43 percent by coal-burning plants (figure 3).

COAL

Of the total coal resources of Illinois (about 190 billion tons in ground) only 5.3 billion tons has recovered during more than 100 years of mining. An estimated 4 to 5 billion tons of coal is considered unminable, because of past mining practices. Of the remaining resources, up to 30 billion tons may be recoverable when certain conventional economic, technological, and legal factors are considered. Estimates of coal resources available for commercial development may be significantly less, however, when other factors such as environmental and geological constraints, have been carefully assessed.

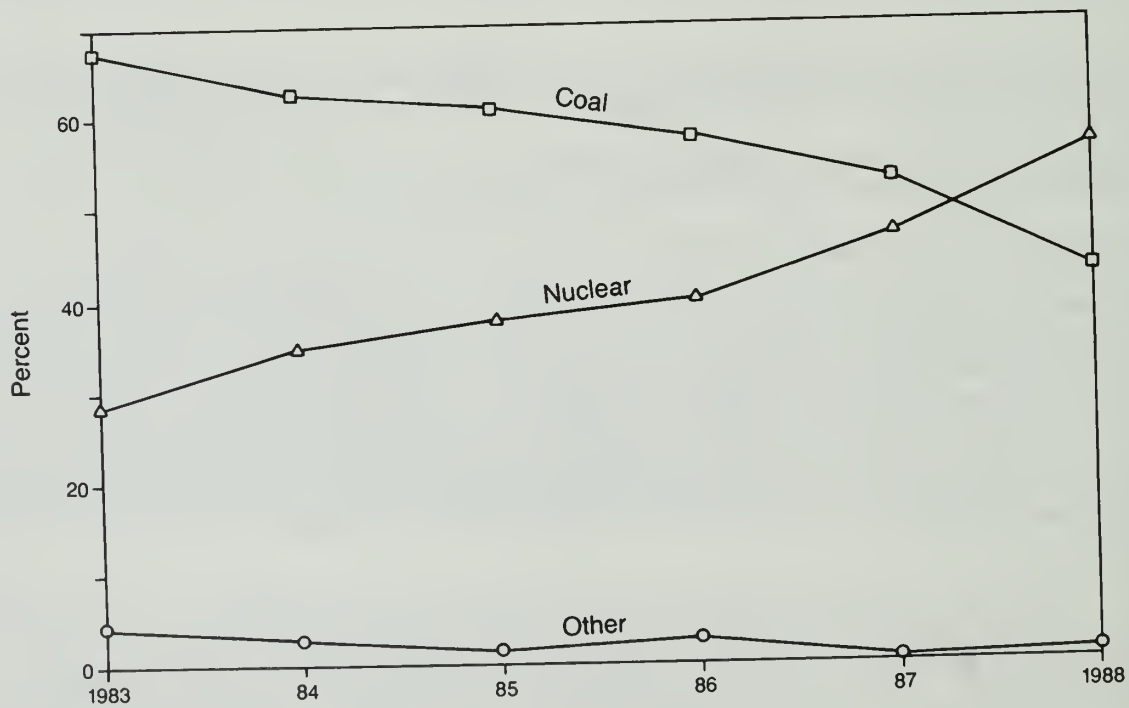


Figure 3 Prime fuels for generating electricity in Illinois in 1988.

New acid rain legislation will require removal of most of the sulfur from coal itself or from the combustion gases after burning. The Survey is making a major effort to develop and improve coal desulfurization processes at both precombustion and postcombustion stages, and to develop efficient methods of removing other deleterious elements such as chlorine, nitrogen, and ash-forming minerals from coal. Postcombustion desulfurization research at the Survey focuses on dry injection of a high-surface-area hydrated lime. Using this desulfurization method with existing boilers could be much less expensive than would other methods of sulfur reduction, and may enable existing power plants to meet intermediate and long-term sulfur dioxide emission goals.

Markets for high-sulfur coal remain weak, and this factor has a negative impact on coal exploration and mine development. Coal industry developments in 1988-89 include the following: The Peabody Coal Company is expanding its Universal surface mine from Indiana into Edgar County, Illinois; pit development is underway, but no production has been reported yet. The Embarras No. 1 mine of AMCO Illinois Mining Company, a small, new underground mine in a relatively low-sulfur coal reserve area, reported its first significant production in 1988 (13,000 tons). The Cutler Mining Company is readying its Kathleen Mine for production later in 1989; this will be a punch mine into the Herrin Coal of the highwall of the Captain surface mine of Arch of Illinois. The Cottonwood Coal Company is developing a strip/auger mine to recover coal from a small reserve block in the Herrin Coal of Williamson County. Lorenzo Mining's J.S. & L. Mine No. 1 has ceased production after producing 23,550 tons in 1988. Two major coal mining companies (Zeigler and Old Ben), which have been active in Illinois for many years, announced that they are for sale. Most of the activities for mine development are in small operations that have little impact on overall production trends.

Coal Database Management

Coal Resource Information System, *C. Treworgy, Bargh, Pollock* Exposed coal and fault traces from recently published geologic maps were digitized and added to the ISGS computerized database on the coal resources of Illinois. Data were also digitized for nine coal seams in the Kentucky portion of the Paducah Quadrangle. This information will be used for maps to be produced for the Paducah 2°x1° quadrangle CUSMAP project in FY90.

Coal Stratigraphic Information System, *C. Treworgy, Sroka, Finley, Pollock* Stratigraphic data on 457 holes were added to the database under a contract with the U.S. Geological Survey (USGS) that ended in December, 1988. Copies of these data were supplied to the USGS for their National Coal Resources Data System (NCRDS). Work began on a new contract with the USGS to compile and correlate stratigraphic data from an additional 300 drill holes. The data collected will be used for a number of internal projects as well as for supporting USGS efforts to build a national database on coal resources. Stratigraphic data for an additional 3,445 holes were added to the Coal Section's database during this period. These data, resulting from past projects conducted by staff of the Coal Section, had previously been available only in paper files.

Coal Mine Information System, *C. Treworgy, Bargh* Outlines of active mines are being updated to show the extent of mining as of January 1, 1989. New county maps (1:100,000 scale) of mined-out areas will be available in the fall of 1989. A prototype map (scale, 1:24,000) showing the extent and type of coal mines was produced for the Springfield West 7.5-minute quadrangle. This type of map is designed to be used by homeowners, developers, local governments, and others to determine if properties are undermined. Each mine was thoroughly researched and all mine outlines were redigitized to incorporate additional detail and obtain more accurate placement of mine boundaries than is available from the existing computer database. Efforts are underway to obtain funding to produce additional maps in this format.

Coal Exploration Records, *Frankie, Bargh* The decline in explorational and developmental drilling for coal that began in the early 1980s continued in 1988. Twelve companies filed 637 plugging affidavits with the Illinois Department of Mines and Minerals, compared to 689 in 1987; 1,400 in 1986; 1,900 in 1985; 1,500 in 1984; and 3,800 in 1983. Only 61 of the wells drilled in 1988 are far enough away from active mines to be classified as exploration wells; this is a

significant decline from the 100 wells drilled the previous year. Most of the drilling (314 holes) was near active surface mines in Edgar, St.Clair, and Jackson Counties. The remaining (262 holes) were drilled near active subsurface mines scattered throughout the coal-bearing area of the Illinois Basin. The most active company was Consolidation Coal Company (301 wells). During the first half of 1989 the Survey received 240 plugging affidavits. About 26 of these may be exploration holes; the rest are related to mine development.

Mobil Oil Company released about 750 coal exploration records; these were part of the 3,445 records added to the Coal Section's computer database this past year. Another company donated 200 detailed records on coal exploration holes from east-central Illinois to the Coal Section's confidential files. Information from these records is now being recorded on Coal Section forms for entry into the computerized database and the collection of hardcopy records.

Cooperative Research on Coal Resources, Quality, and Mining of the Springfield Coal, *C. Treworgy, Damberger, Harvey* Data on the Springfield Coal from the Kentucky, Indiana, and Illinois State Geological Surveys were compiled into a computer database to support cooperative research. The initial product from the database was a base map showing state and county lines, the limit of the Pennsylvanian, and the outcrop of the coal. The database is being expanded to include mines (deep and surface), faults, channels, and stratigraphic and coal-quality data.

Coal Mining Geology

Stability of Partial-Extraction Mine Workings, *Damberger, DeMaris, Chugh (Southern Illinois University)* A cooperative study to identify mine characteristics, conditions, and procedures for the design of stable partial extraction room-and-pillar mining areas in Illinois is being undertaken with the Department of Mining Engineering at Southern Illinois University, Carbondale. The Survey is providing a consultant to a group of engineers at SIU-C for a study of geologic conditions in underground coal mines. The project is supported by the Illinois Mine Subsidence Research Program. Field work in six mines was completed and a draft report has been compiled.

Coal Resources

Availability of Coal Resources, *C. Treworgy* Work began on this project sponsored by the U.S. Geological Survey (USGS) to examine in detail the availability of coal resources for mining in selected study areas throughout the state. The project will assess the amount and location of Illinois coal resources that can be economically mined under current conditions. The project will examine the impact of a number of factors that have never been fully considered in coal resource evaluations in Illinois. These factors include the ratio of the thickness of the glacial overburden to the bedrock overburden, thickness of interburden between seams of minable thickness, stability of roof and floor materials, land use, and surficial hydrography. Results from each study area will be extrapolated to other coal resources in the state that have similar geologic and geographic conditions. Funding received from the USGS will allow us to begin analysis of the first study area (a 7.5-minute quadrangle).

Coal Resources of the Dekoven and Davis Coals in Southeastern Illinois, *Jacobson* The potential for the presence of coal resources and reserves in southeastern Illinois has never been studied systematically, yet these two coals, which are generally close together, have been mined for many years in southeastern Illinois and are judged to have considerable resource potential.

• **Part 1. Saline and Gallatin Counties** More than 1,500 drill hole records were interpreted and results were entered into a database on the Prime 9955 computer. From these data a series of maps including coal thickness, coal depth, and coal structure have been generated. In addition, maps showing the thickness of the Dekoven-to-Davis interval, the Dekoven-split interval, and the sandstone percentage for these two intervals have been generated. Programs to calculate and tabulate resources will be written as part of another project.

• **Part 2. Hamilton and White Counties** Work began on the collection of stratigraphic data for part 2 of this project while the coal resource calculation/tabulation programs were being developed for part 1. More than 300 drill hole records were entered into the stratigraphic database.

Coal Characterization

Spatial Distribution of Organic Sulfur in Selected Illinois Basin Coals, *Harvey, Demir, Lowry* Specific knowledge of the variability of organic sulfur is needed for designing efficient processes to remove sulfur from coal. One major problem with electron microscope methods has been the difficulty of identifying particular macerals or submacerals. A method to accomplish this was applied to determine the distribution of organic sulfur in the macerals in five Illinois Basin coals.

Using an optical microscope equipped for fluorescence with dry objective lenses and for photography with an instant camera, Survey researchers identified and recorded the locations of macerals on a gridded specimen (standard epoxy-mounted pellet). After the specimen is briefly etched in a low-temperature asher, the recorded macerals can be readily located and the organic sulfur can be determined in a scanning electron microscope equipped with an energy-dispersive X-ray analyzer (SEM-EDX). (Organic sulfur, as applied in this study, is the sulfur content at spots within macerals where no mineral matter is detected.) Quantitative results were obtained from a calibration curve based on ASTM and SEM-EDX analyses of three hand-picked lithotype samples. Results for five other samples agree (within 10 percent) with results obtained by the ASTM method.

The organic sulfur content of maceral particles is quite variable. Spot values along traverses across individual particles may differ from the mean value by as much as 20 percent. Analysis of vitrinite, liptinite, and inertinite group macerals from the five coals indicates that the mean organic sulfur content is generally highest in sporinites, lowest in inertinites, and intermediate in vitrinites. The mean sulfur level in each of the group macerals times the maceral's abundance in the coal yield results closely matching the bulk (ASTM) organic sulfur content of each coal.

Mineral Matter in Coal, *Harvey, Lowry* The mineral matter content of the premium coal samples is being determined to provide baseline data for researchers using these samples. Premium coal samples are those specially prepared in and sealed in nitrogen gas to prevent oxidation. This bank of premium coal samples is maintained by the Argonne National Laboratory (ANL). The samples are provided to researchers around the world by ANL. The users are mainly chemists and chemical engineers who are developing new processes for utilization of coals and who need the baseline data to fully interpret their research results.

Representative blocks of the eight samples in the program were obtained from Dr. K. Voores, manager of the ANL project. The blocks were examined under a microscope at 10 to 20 magnifications and an average of three blocks for each sample was selected as representative. Each block was mounted in epoxy and polished. Petrographic and scanning electron microscopic analyses of the composition and distribution of mineral matter is planned.

Distribution and Forms of Chlorine in Illinois Basin Coals, *C.-L. Chou* The first International Conference on Chlorine in Coal will be held in Chicago in October 1989 under the auspices of the Center for Research on Sulfur in Coal (CRSC) and Electric Power Research Institute (EPRI). The conference will bring together experts from the United States and overseas (especially the United Kingdom) to discuss this topic.

Coal Beneficiation Data Studies, *Kohlenberger, Lytle, Kruse* Work is progressing on the identification of correlations between mineral matter content and calorific value and/or organic sulfur content of beneficiated coal samples that are the products of past research projects at the Survey. Analysis of the extensive coal database is yielding results that are being successfully applied to predict organic sulfur values in aggregate flotation fractions for a number of Illinois coals. Other potential uses of the study include applications to the classification system of coals by rank by providing a more accurate determination of Btu content.

Stable Sulfur Isotope Characterization of IBCSP No. 7 Coal Sample, *Hackley* A sample in which a significant difference exists between the isotopic composition of the pyritic and organic sulfur has been included in the Illinois Basin Coal Sample Program (IBCSP). The different forms of sulfur (sulfatic, pyritic, and organic) were extracted and quantitatively determined on five splits of the sample. The isotopic compositions of these forms were determined for two of the splits and show a difference in composition of approximately 21 mass units per mil between the pyritic and organic sulfur. This large difference makes the sample useful for coal desulfurization studies employing the "stable isotope tracer method" developed at the Survey for monitoring sulfur reactions. Funding for the program has come from the Illinois Coal Development Board through the Center for Research on Sulfur in Coal.

Clay Mineralogy of Coal-Related Strata, *Hughes and Moore* Knowledge of the origin of clay minerals in coals, underclays, shales, claystones, sandstones, and limestones of the Pennsylvanian System of the Illinois Basin is essential for developing an understanding of the origin, distribution, and properties of coal and the competency of the overlying and underlying strata. This knowledge can also be applied to the exploitation of industrial mineral resources and petroleum associated with these strata. Recent studies have focused on mixed-layered kaolinite/smectite (K/S), a relatively rare clay mineral that results from intense soil-forming activity. K/S is more common than previously reported, and its occurrence indicates a unique environment of soil formation. A higher ratio of kaolinite:smectite indicates greater weathering intensity, and K/S ratios can be used to estimate weathering intensity in strata of various ages. A chapter on underclays has been prepared by Hughes, DeMaris, and White for a book on paleosols (ancient soils).

Implications of an "Ordered" Heteroatom Distribution in Coal, *Kruse* Little is known about the spatial distribution of heteroatoms (nitrogen, oxygen, and sulfur) in coal, but there are reasons to believe that heteroatoms in coal may not be randomly distributed. For example, coal is derived from biological materials that had their functional groups in specific patterns, and macromolecules with ordered functional groups are known to react with one another by hydrogen bonds, coordinate covalent bonds, and ionic bonds to produce specific shapes in which the functional groups are in close proximity to one another.

If an ordered heteroatom structure actually exists, the project is designed to describe the implications that could result from this condition, and if possible, a resource document useful for persons appraising new approaches to coal research will be produced. Such a document should identify applied research that might be successful if an ordered structure actually exists. A CRSC-funded literature search did not identify many references that included all three heteroatoms in the context of a discussion involving the macrostructure of coal.

Coal Cleaning: Physical and Microbial

Advanced Physical Fine Cleaning by ISGS Aggregate Flotation, *Lytle, Rapp, Kohlenberger, Caldwell, Summers, Kruse* To find improved methods of removing inorganic sulfur, as well as other mineral matter, the Survey has been investigating advanced froth flotation of fine coal as a precombustion desulfurization method. In this method, separation is achieved by preferentially floating fine coal particles from pyrite and other mineral matter through selective attachment of microbubbles to the coal. This work has resulted in a greater understanding of reagent systems, equipment parameters, particle-size effects, pyrite and mineral matter liberation, flotation selectivity, and flotation rates. Various reagents, mainly alcohol, surfactants, kerosene, and combinations of these, have been tested to determine their effectiveness for floating fine Illinois coal. The method can be used to clean finely ground coal or to recover coal from a preparation plant fine-waste stream by using either conventional, easily scaled-up sub-aeration cells and/or advanced columns.

Results indicate that when used with a frothing alcohol, small dosages of surfactants and/or higher dosages of kerosene can decrease overall reagent requirements, increase flotation rates, and boost Btu recovery. For preparation plant waste streams containing high levels of mineral

matter, the most effective reagent package is generally one using alcohol/kerosene with small dosages of surfactant added to increase flotation rates. For plant-washed samples, Alcohol/surfactant systems were found to be an effective alternative to commonly used alcohol/kerosene systems.

Future work in this area will focus on applying the reagent database to alternative flotation equipment. A 3-inch-diameter advanced flotation column was recently obtained on loan from the Deister Concentrator Company, Incorporated. The potential for column flotation for Illinois coal and the potential for using this technology to improve commercial flotation practice will be investigated.

Evaluation of Reagent Selectivity in the Flotation of Coal, *Kruse, Read, Rapp, Summers, Ruch, Lytle, Meyers (Southern Illinois University)* The Electric Power Research Institute (EPRI) tested a proprietary reagent package developed by the Survey and Southern Illinois University against the conventional coal flotation reagents, methylisobutyl carbinol (MIBC) and No. 2 fuel oil (FO), at a 0.5 ton/hour coal feed rate in its Coal Quality Test Facility at Homer City, Pennsylvania, in April 1988. EPRI covered the cost of the tests and analyses, and the Center for Research on Sulfur in Coal paid for the reagents. ISGS staff members delivered the reagents and advised on dosages of the ISGS/SIU-C reagent package to use. Consolidation Coal Company provided Herrin (Illinois No. 6) Coal for the tests from Burning Star No. 4 mine.

Results indicated that it is unlikely that the Survey's reagent will outperform MIBC/FO for 100-mesh coal, but that it might equal it under some circumstances. Interpretation of results for finer (minus 325 mesh) coal was complicated by the possibility that differences in feed ash were due to dilution with ceramic grinding beads admitted by failure of a screen in the fine-grinding mill. The Survey reagent outperformed MIBC/FO for the minus-325 mesh coal, but the lack of uniformity of the feed (almost 5% higher ash for the feed used in the Survey reagent tests) leads to questions about the apparent better efficiency of the Survey reagent in cleaning minus-325 mesh coal. More tests are needed to confirm the efficiency of the Survey reagent package in column flotation.

Engineering Development of Advanced Physical Fine-Coal Cleaning Technologies, *Lytle, Rapp, Kohlenberger, Kruse, Chaven, Hurley, Henry* The Survey is helping Kaiser Engineers develop a froth system for the U.S. Department of Energy to clean finely ground coal. The goal is to remove 90 percent of the pyrite while retaining 90 percent of the Btu. Survey scientists will be testing the effectiveness of standard subaeration cells and developing reagent systems to help achieve this goal—whatever flotation equipment is used. When a flotation approach is chosen, Survey personnel will be consultants for the large-scale tests to be conducted at 3 tons per hour.

Comparison of Column Versus Subaeration Cells for Flotation of Illinois Coal, *Ehrlinger, Lytle, Kruse, Rapp* Flotation tests were done with a sample of IBC-106, an Illinois No. 5 coal from Indiana using various reagent systems. Results from tests with a column developed by Virginia Polytechnic Institute and State College and a standard subaeration cell were compared. For a given reagent system, use of the column resulted in greater ash and pyrite removal than that achieved by the subaeration cells. Use of the Survey's alcohol/surfactant reagent system resulted in increased flotation rates in both the column and subaeration cell as well as greater ash and pyrite removal in the column.

Particle-Size Enlargement of Fine Coal or Char Using Lignocellulosic Residue from TVA's Biomass Program, *Ehrlinger, Kruse, Rapp, Chaven, Rostam-Abadi; Strickland, (TVA and Poo Chow, University of Illinois)* Finely divided solids result from coal cleaning processes such as the ISGS Aggregate Flotation Process. The marketability of these clean fuels would be improved by enlarging the particle size through the use of binders. The TVA Biomass Fuels program uses plants—low grade trees, crop residue, and other materials—for the production of ethyl alcohol. The second stage residue, a lignocellulosic waste, remains after a major fraction of the cellulosic components has been hydrolyzed to component sugars. Under proper conditions of temperature and pressure, the lignocellulosic residue from processing a variety of agricultural wastage may be

an excellent binder for briquetting or extrusion pelletization. The Forestry Department of the University of Illinois can take the fine coal and the lignocellulosic residue and form it into durable pellets, using only increased temperature and pressure. A functional pellet having excellent Btu content and a much lower sulfur content than the feed coal can be made by this process. Optimization of the process is required to improve the overall pellet parameters, compressive strength, Btu content, and sulfur content. Combustion and weathering tests remain to be conducted on optimum strength pellets.

A Method for Improving Sulfur Capture Using Coal/Sorbent Pellets, *Rapp, Lytle, Moran, Chen, Hackley, Kohlenberger, Rostam-Abadi; Berger (University of Illinois), Griggs (CERL)* Modern coal mining methods have led to an increased amount of coal fines generation. These fines are often not processed because there is no market for finely ground coal. Disposal represents not only a lost opportunity for profit but also increased costs for waste disposal. If an efficient, cost-effective pelletization method can be developed to produce a clean burning fuel, marketability of these fines would increase substantially.

An integrated approach will be investigated; this approach consists of a physical coal cleaning pretreatment step and pelletization with lime or calcium silicates (cement) to produce strong, clean-burning coal/sorbent pellets. To determine the feasibility of this approach, combustion tests will be conducted on pellets from two levels of physical cleaning, two sorbent levels, and two pellet porosities at temperatures ranging from those common in fluidized bed combustors (850°C) to those found in industrial stoker boilers (1350°C). A possible application of this approach would be to use fine coal from the advanced flotation processing waste stream as feed.

Chlorine Removal from Coal by Wet-Grinding and Leaching Processes, *C.-L. Chou, Chaven, Demir, Rostam-Abadi* An effective process for removing chlorine from Illinois coal was developed with the support of the Center for Research on Sulfur in Coal. Coal was crushed to -6 mesh and then wet-ground in a stirred ball mill to -200 mesh. The slurry was filtered to generate a filter cake that was subsequently leached with hot water to remove remaining chlorine. The chlorine content was reduced from 0.42 percent in raw coal to 0.28 to 0.33 percent in the filter cake, a 24 to 33 percent reduction. Leaching of chlorine from the filter cake with hot water further reduced the chlorine content in clean coal to 0.21 percent (50% reduction). Grinding coal to a finer particle size than -200 mesh and adding ammonium hydroxide during wet-grinding and water-leaching effectively increased the amount of chlorine removed from coal.

Production of Super-Clean Coal by Wet-Grinding and Selective Flocculation, *C.-L. Chou, Chaven* This project was initiated to develop a physical cleaning process for removing chlorine and sulfur from Illinois coal. The proposed flow sheet includes (1) a wet concentrating table process to remove coarse pyrite, (2) a wet-grinding step to liberate fine pyrite and dissolve chlorine in the process water, and (3) a selective flocculation step to separate coal from mineral matter. A proposal submitted to CRSC in May was approved for funding starting September 1, 1989.

Microbial Pyrite Suppression from Illinois Coals: Microbiology and Chemistry, *Risatti, Broeren* This study is part of a joint effort between the Illinois State Geological Survey and Northwestern University. The objective of the Survey's part of the project is to isolate and identify microbiological by-products that can be used to enhance physical desulfurization of Illinois coals. Historically, microbial methods for desulfurization of coal have focused on removal of sulfur by biological oxidation and subsequent leaching of sulfate. Earlier work on this project indicated that bacterial cultures could wet pyrite surfaces and act as suppressants in physical separation processes.

Pyrite was effectively suppressed by supernatants from cell preparations of *Bacillus subtilis* in addition to *E. coli* K12, but not by supernatant from cells of *Pseudomonas putida*. With *B. subtilis* it was possible to suppress approximately 65 percent of the mineral pyrite used in the micro-flotation assays. Analysis of active fractions of the supernatant indicated that pyrite

suppression increases with an increase in protein concentration. Assays with nutrient broth, a protein-rich solution, also suppressed approximately 55 percent of the pyrite, lending further support to the theory that the suppressant is proteinaceous. Ultrafiltration of bacterial supernatant and nutrient broth indicated that the active component has a molecular weight of 30- to 100-thousand Daltons. The Illinois Coal Development Board, through the Center for Research on Sulfur in Coal, funded this project.

Coal Cleaning: Chemical and Thermal

Desulfurization of Illinois Coal Using Carbon Monoxide and Ethanol, *Shiley, Wu, Brewer, Adomaitis* The carbon monoxide-ethanol (CO/EtOH) desulfurization process, a comprehensive multi-step process for removing sulfur from Illinois high-sulfur coal, is based on the generation of an iron sulfide catalyst ($Fe_{1-x}S$) from in-situ mineral pyrite followed by reaction with an ethanol vapor stream for organic sulfur removal. In the laboratory, this process has produced a coal-like product that can meet the 90-percent sulfur reduction requirement of the Federal Revised New Source Performance Standard Act.

The CO/EtOH technology is being developed with funding supplied by a 3-year Illinois General Assembly grant (administered by the Illinois Department of Energy and Natural Resources), and the Illinois Corn Marketing Board (ICMB). The goal of this research is the demonstration of a combined three-step technology in a continuous-feed, gas-flow reactor (CFU) under conditions that remove both inorganic and organic forms of sulfur using consecutive carbon monoxide and ethanol treatments. Reaction rate expressions essential for the development of a CFU design are being calculated from data acquired in a new ISGS plug flow reactor system.

The reactor unit is being designed with the assistance of an engineering consulting firm and several consultants. Under current CFU design goals, we seek to achieve (1) a reactor that can process 2 to 20 pounds of coal per hour, (2) a maximum temperature of 500°C, and (3) a maximum pressure of 500 psig. These reactor specifications should permit operations under conditions more severe than those required for adequate desulfurization.

In accompanying research, a first-phase contractual agreement with the University of North Dakota Energy and Mineral Research Center (UNDEMRC) for testing the CO/ethanol technology in fluidized-bed reactors has been finalized. A 1-pound/hour fluidized-bed reactor (FBR) is being used in preliminary tests with carbon monoxide and ethanol that include eight 12-hour experiments. Test variables include particle size, temperature, pressure, and reactant concentration. The overall scope of the program includes the eventual design and construction, if necessary, of a falling-bed reactor by the UNDEMRC, or the use of UNDEMRC's inhouse fluidized-bed reactors of 4, 30, and 100 pound/hour capacities.

A cooperative agreement is being negotiated with the Illinois Department of Energy and Natural Resources, the Illinois Corn Marketing Board, the Illinois Corn Growers, the Ohio Corn Marketing Board, and Ohio University for further development of the CO/Ethanol technology. This agreement will provide funding to the Survey and Ohio University to further develop the Survey's one-step advancement (patent pending) on the CO/ethanol process in a fluidized-bed reactor system. The one-step process utilizes only ethanol and a reaction accelerator to remove both inorganic and organic sulfur from Illinois high-sulfur coal.

Chemical and Kinetic Study of Pyrite Conversion Under Various Atmospheres, *M. Chou, Hughes, Moore, Glass, Shiley* In carbon monoxide/ethanol coal desulfurization, troilite (FeS) formed from the breakdown of pyrite and marcasite is thought to be a catalyst for removal of strongly bonded organic sulfur. The purpose of this project is to study the transformation of pyrite to 6-8 pyrrhotites, intermediates to the formation of troilite, under various atmospheres (hydrogen, carbon monoxide and ethanol). Using improved methods of temperature control, 15 pyrite-hydrogen reactions were carried out at 450°C for times varying from 5 to 40 hours. Two pyrite-ethanol reactions were carried out at 350 and 400°C. X-ray diffraction (XRD) is being used to monitor the pyrite transformations. Variations in pyrite particle size, heating rate and maximum

temperature, and reduction by hydrogen sources versus carbon monoxide lead to differences in pyrrhotite composition and crystallinity, which may alter their catalytic properties. This project is nearly complete.

Sulfur Migration During Hydrodesulfurization (collaboration with Southern Illinois University), *Hackley* Two ^{34}S-labeled compounds, 2-thiomethyl-dibenzothiophene and 4-thiomethyldibenzothiophene, were prepared by researchers at Southern Illinois University. These compounds were used to study migration of organic sulfur into troilite (FeS) under hydrodesulfurization conditions.

Hydrodesulfurization experiments, using a quadrupole mass spectrometer (QMS) to analyze the H_2S profiles exiting the reaction system, were completed. The profiles obtained from the QMS were quite different for runs made with and without the troilite present. This result indicates that some of the labeled sulfur from the organic compound has reacted with or been sorbed by the troilite. Chemical extraction and isotopic analysis of the reacted inorganic sulfide sulfur showed that a significant part of the ^{34}S labeled sulfur had indeed reacted with the troilite. The QMS data also indicated that some labeled organic sulfur reacted with or was sorbed by the charcoal medium.

Coal Desulfurization Using Perchloroethylene, *Chaven, Hackley, Kruse, Ruch; Buchanan (Eastern Illinois University)* The potential of perchloroethylene (PCE) extraction to desulfurize coal is the focus of a current collaborative research effort by the Survey and Eastern Illinois University co-sponsored by EPRI and CRSC. Papers were presented at the Second International Rolduc Symposium on Coal Science by Kruse and at CRSC and EPRI by Buchanan.

Results from experiments with Illinois No. 6 Coal suggest that pyrite is the sole source of elemental sulfur extracted from coal by hot PCE. Elemental sulfur and sulfate coproduct are produced by pyrite oxidation. No evidence that elemental sulfur is produced by some transformation of organic sulfur during PCE extraction was found. Elemental sulfur was identified, and the amount of elemental sulfur quantitatively correlated with the amount of ASTM sulfatic sulfur in all weathered coals. A negligible quantity of elemental sulfur was found in the Argonne Premium Coal No. 3, a parent coal of several weathered coals used in this study. IBC-107, which has different $^{34}S/^{32}S$ ratios in the organic and inorganic sulfur fractions, was also extracted with PCE. Sulfur isotopic ratio analyses of the sulfur in the products from the PCE extraction indicated that the source of the elemental sulfur in the sample was pyrite. The ratio of elemental sulfur to sulfatic sulfur and the degree of isotopic fractionation taking place in producing these products from pyrite coincide with published data for pyrite oxidation augmented by a specific strain of bacteria. The suspected mechanism for pyrite oxidation will be studied in the coming year.

Lignin-Augmented Bituminous Coal Depolymerization: A Route to Clean Fuels, *Kruse, Chen, Ehrlinger; Porter (Carbon Resources Technology, CRT); Bourke (General Motors, GM); Knudson (University of North Dakota Minerals & Energy Research Center, UNDMERC); Strickland (Tennessee Valley Authority, TVA); Uzkan (GM)* Phenolic solvents promote depolymerization (solubilization) of western low rank coal in the presence of aqueous sodium ions and carbon monoxide (CO) under intermediate-severity conditions (340 to 350°C and 1800 to 2000 psig pressure). The granular product of such chemistry, called ChemCoal by its developer, Carbon Resources Technology (CRT), has low-sulfur (approximately 0.3%), low ash (approx. 0.5 percent), and high volatile content; it has passed preliminary screening tests by Allison Division of General Motors for suitability as a gas turbine fuel.

This new project involves testing Illinois Basin coal under modified ChemCoal process conditions with lignin added to make up for a potential deficiency of phenolics in bituminous coal. The initial source of lignin will be by-product residue from Tennessee Valley Authority's (TVA) process for producing grain alcohol from wood. Tests will be made at the University of North Dakota Minerals & Energy Research Center (UNDMERC) in equipment previously used under U.S. DOE funding for testing of western coal. The Survey will characterize products and provide chemical

engineering assessment of the process as modified. U.S. DOE is contributing half the funds for the UNDMERC tests, and two divisions of General Motors will evaluate products as fuels for gas turbines and diesel engines.

Coal Combustion

Development of High-Surface-Area Hydrated Lime, *Rostam-Abadi, Moran* Calcium-based sorbents with higher surface area are generally more reactive for sulfur dioxide sorption. Survey engineers have developed a proprietary process for producing high-surface-area (HSA) hydrated lime. A bench-scale hydrator that can produce 10 pounds of hydrates per batch was constructed.

An extensive optimization study was conducted with several different limes to evaluate the effect of lime properties and hydration conditions on surface-area development. The surface areas of hydrates made with commercial limes ranged from 25 to 48 m^2/g compared with areas of 37 to 80 m^2/g for hydrates made from limes prepared in our laboratory. Hydrate surface area generally increased with increasing lime-surface area.

Three hundred pounds of HSA hydrate were produced from a commercial lime (made from an Illinois limestone) in the bench-scale hydrator. The particle size and surface area of the HSA hydrate were 2.06 microns and 37 m^2/g, compared with 3.46 microns and 20 m^2/g for a commercial hydrate made from the same lime. The HSA hydrated lime was tested for SO_2 removal performance in CONSOL's 100 kw Coolside pilot unit, in KVB's 146 kw boiler economizer furnace, in EPA's 14 kw innovative furnace reactor, and in a laboratory-scale spray drier unit located at the University of Illinois at Urbana-Champaign. Under Coolside conditions, the maximum SO_2 removal obtained with the HSA hydrate was 56 percent, compared with 49 percent for the best-performing commercial hydrate. Under boiler economizer conditions, the maximum SO_2 reduction achieved was 58 percent, compared with only 32 percent for the commercial hydrate. Under furnace sorbent injection conditions, SO_2 removals approached 80 percent for the HSA hydrate, compared with 60 percent for its commercial counterpart. In the spray drier unit, 43 percent SO_2 removal was obtained with a 29 m^2/g HSA hydrate, compared with 40 percent removal for the commercial hydrate. Thus far the high-surface-area Survey hydrated lime is the most effective lime material tested to date for removing SO_2. Commercial testing and possible application is being planned.

Sorbent Evaluation for Pressurized Fluidized-Bed Combustors, *Rostam-Abadi, Chen, Harvey* The advantages of fluidized-bed combustion (FBC) over conventional pulverized-coal combustion are lower NO_x emissions and in-situ sulfur removal during combustion by the addition of calcium-based sorbents. The FBC process can take place at both atmospheric and pressurized conditions. The pressurized fluidized-bed combustion (PFBC) has the additional advantage of higher energy cycle efficiency. One goal of this CRSC-funded project was to test and identify highly reactive limestones and dolomites from Illinois for sulfur removal in PFBC systems. An additional goal was to gain a better understanding of sulfur capture mechanism and reaction rates of calcium-based sorbents at elevated pressures.

During this past year, sulfation capacity tests were evaluated for ten Illinois limestones under both atmospheric and pressurized conditions. Two size-fractions of calcines (16x20 mesh and 35x48 mesh) were prepared for each of the five limestones and five dolomites. Tests were conducted with the microbalance reactor to determine baseline atmospheric sulfation capacities at 850°C under a simulated flue gas environment. Physical and chemical properties of the carbonate rocks, calcines, and selected of sulfated samples were measured to explain reactivities of the sorbents.

Calcination under a CO_2-N_2 atmosphere improved utilizations substantially, compared with calcination under N_2 only; greater effects were observed for the dolomites. Calcium utilizations for the 16x20-mesh calcines derived from dolomites were 60 to 92 percent, compared with 26 to 33 percent for those derived from limestones. On the basis of the original mass of stones, limestones captured between 210 and 260 milligrams of SO_3 per gram of sorbent and dolomites captured between 290 and 400 milligrams of SO_3 per gram of sorbent. Calcium utilization data were

correlated with physical and chemical properties of the sorbents. Results indicated that MgO content, pore surface area, and mean pore size influenced the calcium utilization, while grain size had negligible effect.

The design, fabrication, and assembly of the pressurized reactor is completed. Sulfation tests will be conducted with two of the dolomitic limes at 5 atm and 850°C under a simulated flue gas environment, and results will be evaluated.

Reactivity and Combustion Properties of Coal-Derived Solid Fuels, *Rostam-Abadi, DeBarr* The reduction in volatile matter that accompanies most thermal and chemical coal-desulfurization processes affects combustion characteristics such as ignition temperature, flame stability, and carbon burnout. The goal of current Survey research is to supply a broad range of combustion characterization data on coal-derived solid fuels.

Three size fractions of an Illinois coal (IBC-101, VM=43.9%), three chars with volatile matter contents of 6, 12, and 15 percent, and a clean coal were studied. Fuel analyses showed that removal of volatile matter reduced sulfur emissions (lb SO_2/MMBtu) of the resulting chars. Chars appeared to be nonporous and had significantly lower surface areas as measured by N_2 absorption and slightly higher surface areas as measured by CO_2 absorption than the raw coal. Chars were also more difficult to grind than coal.

Ignition temperatures of fuels were obtained in an ignitability apparatus and increased with decreasing volatile matter and particle size. Ignition temperatures increased sharply for fuels containing less than 12-percent volatile matter. Burning profiles obtained by a thermogravimetric analyzer showed that smaller size fractions and higher volatile fuels were easier to burn. Chars had seven times higher reactivity in steam than in CO_2. Gasification reactions were much slower than the combustion reaction.

Combustion efficiencies and ash deposition behaviors of fuels were obtained in an entrained flow reactor under conditions representative of coal-fired boilers. Combustion efficiencies increased with increasing temperature, volatile matter and residence time, and decreasing particle size.

Ash deposition studies showed that clean coal produced a deposit that accumulated at a faster rate than did the deposit produced by the uncleaned coal. However, the deposit strength does of the clean coal was less than that of the uncleaned coal.

Investigation of Highly Combustible Char, *Hackley, Liu, Coleman* The objective of this project was to investigate a highly combustible char made from explosively shattered (ES) coal at the Illinois Institute of Technology Research Institute (IITRI). It has been previously shown that hydrodesulfurization can produce compliance solid fuels. Unfortunately, the resulting chars usually have low volatile contents and thus poor combustion properties. Preliminary combustion data collected on the ES coal indicated that it was possible to produce chars with very good combustion properties even though there was less than 10-percent volatile matter remaining in the char. The cost of producing ES coal by the IITRI process is too high for a commercial process; therefore, future investigations will be CO_2-induced ES coal developed at Purdue University. The pressures and temperatures necessary for producing CO_2-induced ES coal are much lower than those of IITRI's process. The capability of producing low-sulfur, highly combustible chars could significantly expand the market for Illinois high-sulfur coals.

Elemental Mass Balance Studies for the Chiyoda SO_2 Scrubber at Abbott Coal Fired Power Plant, *Cahill, Henderson, Steele* The Analytical Chemistry Section is characterizing the coal, limestone, fly ash, and by-product gypsum as part of the testing phase of the Chiyoda scrubber at the University of Illinois Abbott Power Plant. This work is with the Institute for Environmental Studies with funding by EPRI through the Radian Corporation. Approximately 217 samples of

limestone and gypsum have been characterized for carbonate-carbon content. Trace element analyses by inductively coupled plasma emission spectroscopy (ICP) were completed on 60 samples from the process streams.

Liquids and Gases from Coal

Production of Premium Liquids by Mild Gasification, *Kruse, Williams, Cooper, VandenBrook* The purpose of this project is to produce and characterize coal liquids by using a mild gasification approach. Mild gasification is understood to be a low-temperature and low-pressure pyrolysis process in which the products envisioned are a premium coal-derived oil, reactive high-volatile matter char, and low Btu gas.

Design and construction of a 3-inch reactor system to produce great quantities of oil was completed. During the design and construction period, a 1-inch reactor system was used to test the effects of several additives on mild gasification products. The results indicated that lime (CaO) would be a useful additive, and its behavior as an additive was later studied in the 3-inch reactor.

The 3-inch reactor system was used in three statistically designed experimental sets. Experiments with the 3-inch reactor resulted in higher oil yield, lower char yield, and lower oil hydrogen to carbon ratio (H/C) than produced in similar earlier experiments with the 1-inch reactor. The effect of temperature on the oil H/C ratio was small over the 450 to 550°C range; however, higher H/C ratio oils were obtained at 400 than 600°C. Increased temperature resulted in significantly increased oil and gas yields and lower char yields. Treatment time had little effect of any of the response variables. Higher heating rates resulted in lower char yield, higher gas yield, and oils with lower H/C ratio. A steam environment produced slightly higher H/C ratio oil than hydrogen. Over the range tested, gas flow rate resulted in only small effects on response variables. The addition of 20 wt percent CaO produced an oil with a much lower viscosity than the other oils produced. A heavy and light oil study indicated that hydropyrolysis from 550°C to 850°C produces mostly gas. The small amount of liquid collected over this temperature range had the lowest H/C ratio of all other oils produced. Detailed oil analyses on selected oil samples indicated greater market potential as specialty chemicals than as transportation fuels.

Coal/Oil Coprocessing Studies, *Kohlenberger, Lytle, Kruse, Williams, Hackley* A series of preliminary tests was undertaken by Minerals Engineering Section staff in association with Hackley, to study the effects on product yield and quality of the low-temperature pyrolysis of various coal/oil mixtures. Although reports from elsewhere have been very encouraging, our experiments to date have failed to produce any appreciable synergistic effects.

Technical Support Services

Illinois Basin Coal Sample Program, *Kruse, Harvey, Chaven, Ehrlinger, Rapp, Summers, Vorres, ANL* The Illinois Basin Coal Sample Program was established in 1983 to facilitate comparisons of research data among laboratories conducting basic and applied research on Illinois Basin coal and assure that researchers have reproducible samples for up to 5 years or more. Each year since the program began the demand for samples has increased.

Prior to the 1988-89 fiscal year six samples were included in the program. During the 1988-89 period three additional coal lots were added to the program: IBC-107, 150 pounds of naturally occurring, isotopically labeled Herrin (Illinois No. 6 seam) Coal; IBC-108, 1000 pounds of a state-of-the-art, physically cleaned, micronized, commercial blend of approximately 80 percent Herrin (No. 6) and 20 percent (No. 5) coals; and IBC-109, three tons of low organic sulfur and high chlorine (No. 6) coal.

Last year 1,865 pounds of coal were delivered to 38 researchers. These samples are popular among researchers, and the data generated by investigators throughout the world using these samples becomes a valuable asset to the state. Analytical analyses of all the samples are conducted semiannually to confirm the reproducibility of the samples and assure users of the continued quality of the samples. In addition, these samples have undergone extensive

characterization for ash composition, ash fusibility, hardgrove grindability, equilibrium moisture, and petrographic analyses. characterization.

Coal Technology Transfer and Information Services

Information on Coal Mining and Geology, *DeMaris, Frankie, Bargh, Damberger* More than 80 requests for information on historical coal mining activity and on the potential coal resources at specific sites were answered by phone or letter. Inquiries come from national, state, and local agencies, and individuals. The most common type of request is concerned with previous mining activity under businesses, homes, and farms. Most of these requests are referred to the Illinois Mine Subsidence Insurance Fund for the purpose of determining the potential of subsidence above abandoned underground mine workings.

OIL AND GAS

The most serious short- and long-term energy problem in the United States was identified in a report by the U.S. Department of Energy as the inadequate supply of domestic petroleum for transportation fuels. Of major concern are the ongoing developments in the oil industry (especially the low oil price) that have had a nationwide impact on the nation's domestic oil production, economic development in oil producing states, and security.

Many stripper wells in Illinois have become too costly to operate and have been shut in. Oil prices have been too low to justify exploration risk. Banks have become reluctant to finance high-risk ventures under low-price scenarios. The lack of capital and research capability are strongly inhibiting the ability of independent oil producers to continue their role as the principal discoverers and producers of hydrocarbon reserves in the lower 48 states.

The result is a rapidly widening gap between consumption and domestic production. Imports recently exceeded 50 percent of the nation's supply of crude oil and petroleum products, putting the United States in a steadily worsening economic position and increasing concerns for security of supplies. The United States' dependency on oil, its current position in the world oil market, the state of the Illinois oil industry, and the anticipated high potential of remaining unrecovered petroleum resources in existing fields have all provided strong incentives for establishing an Illinois-specific, integrated, comprehensive oil and gas research program.

Recognizing these factors, the Illinois State Geological Survey is attempting to position itself to respond to the needs of the state and to be of maximum help to the oil industry of Illinois, especially the independents who continue to provide the stable base for the state's oil and gas operations. The Survey has expanded its program of research and service in oil and gas. Its goals are to help industry find economic means of getting more oil out of the fields already discovered; provide additional ideas and incentives to industry; help identify and promote wise development of Illinois' oil and gas resources; and provide complete and timely information to the oil industry.

To get more oil from existing fields, it is necessary to increase understanding of the nature of Illinois' petroleum-producing reservoirs by acquiring basic knowledge that will help prolong and enhance the productiveness of the state's petroleum resource. Improving recovery efficiency is one of the major objectives of the Survey's expanded program of oil and gas researchers. A properly focused, well-managed, sufficiently financed long-term oil and gas geosciences research program will allow the Survey to

- define the state's remaining unswept mobile oil (currently estimated at 1.5 billion barrels);
- provide otherwise unobtainable research to the Illinois Independent Oil Producers;
- persuade stripper well operators not to abandon access to remaining oil in place;
- develop technology to enhance production from mature fields;
- maintain an industry whose cash flow strengthens the Illinois economy;
- prove that future reserve additions in Illinois can come from extensions to existing fields and intensive directed development of existing fields through geologically targeted infill drilling.

The Survey's Oil and Gas program also aims to aid the independent petroleum industry in exploration and development of Illinois resources by providing the comprehensive data collection, mapping, and subsurface stratigraphic research required to generate new petroleum targets and new techniques for exploiting existing fields and plays. New research emphasis is being placed on how and when oil was generated in the Illinois Basin.

Oil and gas data are made available to the public via (1) an annual report on the petroleum industry in Illinois; (2) a monthly drilling report; (3) oil and gas pay zone maps (showing the geographical area underlain by oil production from individual rock layers); (4) maps showing the subsurface depths of selected strata; (5) special publications; and (5) the Geological Records Unit. This state-mandated repository for well records contains more than 270,000 files (more than 100,000 are oil and/or gas wells.

Oil and Gas Statistics

Annual Statistics and Records, *Huff, Black* From the wells drilled each year, geological records, including well logs, are provided to the Survey by industry in accordance with state laws and regulations.

Number of holes reported In 1988 and 1987

	1987	1988
Oil and gas tests		
New holes	1,729	1,179
Old holes drilled deeper	NP	NP
Service wells		
New holes	69	89
Old holes drilled deeper	NP	NP
Structure tests	0	4

(NP = None processed)

The 1,272 new holes drilled in 1988 resulted in 633 oil wells, 31 gas wells, and 515 dry holes. Illinois ranked 14th in the United States in 1988 in oil production. In 1988 annual production (figure 4) reached an estimated 22,476,000 barrels, 9.3 percent less than in 1987. Discoveries reported included 1 oil field, 7 new pay zones in existing fields, and 13 extensions to fields.

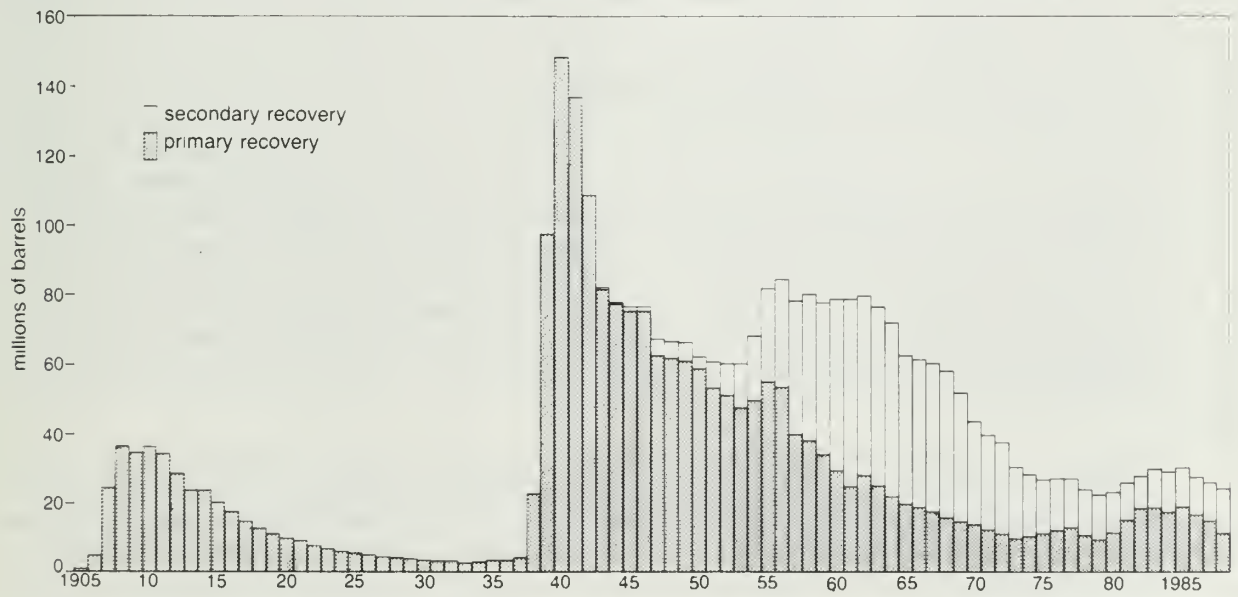


Figure 4 Yearly production of oil in Illinois.

Illinois production in 1988 compared with 1987 (MB=1000 barrels)

	1987 MB/mo	1988 MB/mo	% change from 1987
January	2,000	1,839	-8
February	1,898	1,821	-4
March	2,080	2,000	-4
April	1,985	1,876	-6
May	1,981	1,931	-2
June	1,995	1,971	-1
July	2,050	1,844	-10
August	2,007	1,970	-2
September	1,983	1,860	-6
October	2,029	1,790	-12
November	2,003	1,779	-11
December	2,086	1,795	-14

Eight counties accounted for 51 percent of the reported new oil and gas tests drilled:

County	No. of holes	% state totals
Crawford	193	16.3
Wayne	88	7.5
Lawrence	61	5.2
White	57	4.8
Richland	56	4.7
Jefferson	52	4.4
Marion	49	4.1
Franklin	47	4.0
	603	51.1

Improved Oil Recovery Methods and Concepts

New Program for Improved Oil Recovery, *Oltz, staff* The U.S. Department of Energy recently indicated that of the amount of remaining oil in place in Illinois, 1.5 billion barrels is unswept mobile oil and 4.4 billion barrels is immobile oil. These sizable targets are significant objectives for the Illinois State Geological Survey's oil and gas research and service program. The Survey's immediate research efforts are focusing on the geological characteristics of reservoir rocks (e.g., porosity variability due to depositional environment and distribution of clays within the pore spaces) that affect the location and producibility of petroleum reservoirs. The unswept and bypassed oil controlled by such geological conditions is a promising target for research that could help the nation reduce its shortfall of domestic hydrocarbon production and help Illinois producers increase the state's oil production (fig. 4).

On June 28, 1989, the Department of Energy awarded a $750,000 grant to the Illinois Department of Energy and Natural Resources for the first 12 months of a 4-year program. The State of Illinois matched the grant. These leveraged dollars will fund a project entitled "Research on Improved and Enhanced Oil Recovery in Illinois Through Reservoir Characterization." The 12-task research project will examine subsurface heterogeneities in Illinois oil reservoirs. Staffing of the project has begun.

Geoscience Institute for Oil and Gas Recovery Research, *Leighton, Oltz* The Survey, one of 15 charter members of the Institute, continues to represent Illinois in refining the Institute's goals and direction. The final report on description and prioritization of research needs for oil and gas recovery has been printed. Leighton and Oltz, on behalf of the Illinois Basin Consortium (IBC), presented a project to the Geoscience Board for inclusion as one of seven projects to be submitted to the Department of Energy for possible funding. The state surveys of Illinois, Indiana, and Kentucky cooperated in designing this project, titled "Mobile Oil Recovery Efficiency in Contrasting Geologic Settings—the Illinois Interior Cratonic Sag Basin and the Texas System of Basins." The Geoscience Institute Board approved the proposal for submission to DOE.

Aux Vases Sandstone Reservoir in Zeigler Field, Franklin County, *Seyler* In Zeigler Field, Franklin County, Illinois, approximately 150 well logs were interpreted, and formation tops were picked. The resulting computerized database was used to map the geometry and structure of this Aux Vases Sandstone reservoir. Six closely spaced cores from the Aux Vases Sandstone were acquired. SEM /EDS, XRD, X-ray diffraction, and thin-section analyses are being run on these cores. This characterization of reservoir heterogeneities was scheduled for presentation at the Eastern Section meeting of the American Association of Petroleum Geologists (AAPG).

Basin Core Data Analysis, *Bang, Oltz* Rock and fluid properties were compiled by reservoir and by field. The data include core analysis data, rock lithology, crude oil gravity, sub-sea elevation, and number of wells cored and analyzed. Preliminary results of cluster analysis indicated that the McClosky might be divided into three similar groups, and the Aux Vases and Cypress into two similar groups. Additional geologic parameters and their impact on cluster patterns will be investigated.

Computer Model Development and Installation, *Bang* A cluster analysis computer program was developed and tested on the Mississippian reservoirs. The program, BANG206E, was installed on the Oil and Gas Section PC and is ready for use. The personal computer (PC) version of BOAST II black oil simulators and EOR predictive models were installed and tested on the Oil and Gas Section PC. The installation of BOAST II on the PRIME and VAX computers is underway.

Depositional Analysis Based on Electric-Log Characteristics of Cypress Sandstone (Chesterian) in Illinois, *Seyler* Most petroleum production from the Cypress Sandstone is from sandstones deposited in a deltaic environment in Illinois. Deltaic sandstones can be divided into various facies on the basis of electric log characteristics. It has been found that reservoir quality is largely dependent on which deltaic sandstone facies was deposited. Mapping of Cypress Sandstone bodies in the Parkersburg area shows variation in distribution and orientation between upper, middle, and lower sandstones. An oral presentation was scheduled for the Eastern Section meeting of the AAPG.

New Exploration Methods and Concepts

A Fluvial-Estuarine Valley-Fill Reservoir at the Mississippian-Pennsylvanian Unconformity, Main Consolidated Field, Illinois, *Howard, Whitaker* This manuscript was submitted to the editors of the textbook, *Sandstone Petroleum Reservoirs,* being published by Springer-Verlag. The report discusses the depositional history, diagenesis, and significance of a hydrocarbon-filled sandstone reservoir deposited 300 million years ago along the floor of a 220-foot-deep valley. This study can help in the search for hydrocarbons in reservoirs formed by similar geological conditions.

A Gravity Survey of Marine Field: Case Study for Silurian Reef Exploration, *Heigold, Whitaker* This study, to be published in the Survey's Illinois Petroleum Series, discusses the use of gravity surveying for the exploration of hydrocarbon-bearing Silurian reefs. A gravity survey conducted over the Marine Field in Madison County, Illinois, is used to illustrate how measurement of the local gravity field can aid in this type of exploration.

Residual and derivative mapping techniques applied to the gravity data enabled an accurate portrayal of the reef structure at Marine. Study results, which indicate that similar mapping techniques could be effective in locating buried Silurian reefs in the Illinois Basin, provide a valuable aid to oil and gas explorationists. A poster session was scheduled for the Eastern Section meeting of the AAPG.

Silurian Pinnacle Reef Distribution in Illinois: Model for Hydrocarbon Exploration, *Whitaker* This report suggests that reefs, which have accounted for more than 92 million barrels of Illinois' oil production, are more widespread than had been previously thought. Prospective areas for reef exploration are discussed as well as exploration methods that can be used to locate reef targets. The report has been released as Illinois Petroleum 130.

Preliminary Assessment of Hydrocarbon Potential in Southern Illinois, *Crockett, Oltz* Hydrocarbon exploration has been sparse in southern Illinois, south of the Cottage Grove Fault System. More than 140,000 acres in this area are within the Shawnee National Forest (SNF). Increased interest in hydrocarbon exploration in the region has been noted. Review of the energy mineral exploration potential of the SNF is timely now that the U.S. Forest Service is able to lease portions of the SNF following revisions to the Mineral Leasing Act. Geophysical, well log, rock sample, and geochemical information are being used to better define factors important to the potential generation, migration, and entrapment of hydrocarbons in the subsurface in southernmost Illinois. A poster session outlining current understanding of the hydrocarbon potential in southern Illinois was accepted for presentation at the September 1989 American Association of Petroleum Geologists Eastern Section meeting in Bloomington, Indiana.

Hydrocarbon Entrapment in Devonian Dolomites, *Whitaker* A preliminary appraisal of Lower Devonian oil fields in southwest Illinois indicates that these fields may be related to a regional pinchout of porous, oil-filled Lower Devonian dolomite. Several oil fields had been discovered along this trend, but no geologic explanation for their occurrence had been previously published.

Update of Basinwide Paleogeologic Map of the Sub-Pennsylvanian Chesterian Surface, *Howard, Whitaker* To aid industry in the search for hydrocarbon traps associated with the Mississippian-Pennsylvanian unconformity, an updated and revised version is being prepared of the 1971, *Paleogeologic Map of the Sub-Pennsylvanian Chesterian (Upper Mississippian) Surface in the Illinois Basin,* from Survey Circular 458, by R. H. Howard and H. M. Bristol. Given current knowledge of the location of paleovalleys, explorationists can better define the multiple plays associated with paleovalleys. Revisions contributed by the Indiana and Kentucky Surveys are being combined with Illinois' revisions to produce the basinwide map.

Hydrocarbon Generation and Migration Studies

Source Rock Studies of the Ordovician Maquoketa Group, *Crockett, Oltz, Dickerson, Henderson* Regional study of the Maquoketa Shale, a potential hydrocarbon source rock in the Illinois Basin, continues. Samples from cores and well cuttings were collected for analysis of clay mineral diagenesis linked to maturation, and for evaluation of thermal maturity by Rock-Eval (pyrolysis). Clay mineral studies are part of a proposed cooperative effort by Survey staff and Dennis Eberl of the U.S. Geological Survey. Rock-Eval analysis and regional stratigraphic assessment are conducted by Crockett and Oltz, with chemical support by Dickerson and Henderson. Produced oil and whole rock extract studies are part of a cooperative effort with Michael Kruge of Southern Illinois University. Coordination of Rock-Eval, stratigraphic, clay mineral, and hydrocarbon analyses will be incorporated into a regional evaluation of the hydrocarbon potential of the Maquoketa Shale.

Hydrocarbon Maturation Modeling in the Illinois Basin, *Oltz, Crockett* Advanced computer modeling of maturation of organic-rich sediments in Illinois continues. Four models have been generated that incorporate integrations of time-temperature, kerogen kinetics, matrix conductivities,

compaction and decompaction, and variations in heat flow over time. Simple linear heat-flow assumptions do not work in Illinois. These models have been coupled with conceptual ideas regarding migration.

Oil-Source Potential of the New Albany Shale Group in the Illinois Basin, *M. Chou, Dickerson, Sargent* To evaluate the oil-source potential of the New Albany Shale Group in the Illinois Basin, the hydrocarbon generative potential and the production index of shale samples (cores and cuttings) from throughout the Illinois Basin were examined by the Rock-Eval pyrolysis technique and this information was compared with other available geologic and geochemical data. Results of the first stage of this project involving Rock-Eval screening were presented at the AAPG Eastern Section meeting in September, 1988. The second stage of the project, which involves using a more detailed molecular-level analysis (organic biomarkers) for oil-source evaluation, was temporarily suspended.

Potential Source Rock for the Ordovician Oil in the Illinois Basin—An Organic Geochemical Study, *M. Chou, Kolata, Norby, Shaw, Sargent* The purpose of this project is to examine the chemical fingerprint pattern of the soluble organic fraction of shales from the Joachim Formation (Ordovician System) and/or other older strata and to compare the patterns with those of Ordovician crude oils to search for possible genetic relationships between them. Shale samples from cores and cuttings from southern and southeastern Illinois are being processed for total organic carbon and Rock-Eval carbon evolution analyses. Preliminary evaluation of samples from two wells in Montgomery and Hamilton Counties, Illinois, is expected to be completed by the winter of 1989.

Organic Geochemistry of Crude Oils in Illinois, *M. Chou, S. F. Chou, Dickerson* The ultimate goal of this project is oil-oil and oil-source rock correlation in the Illinois Basin. Gas chromatography was used to obtain gas chromatography fingerprints of 70 crude oil samples. Three characteristic fingerprint patterns (Types I, II, and III) were observed in the crude oils analyzed. Type I, which has a smooth n-alkane distribution, is common for crude oils from younger reservoirs whereas Type III, which has a characteristic odd n-alkane distribution, is characteristic of Trenton (Ordovician) oils. In Type II oils, n-alkanes are distributed in two groups, one in the lower molecular weight region and the other in the higher molecular weight region. Type II oils were relatively rare in the samples studied.

The data in this study imply that Illinois crude oils can be classified as having at least two distinct sources; one originating from an unidentified Ordovician stratum and the other originating from sources younger than Ordovician age, probably the New Albany (Devonian-Mississippian) shale. The results of this study were presented at the Kentucky Oil and Gas Association Meeting in Lexington on June 7-9, 1989.

Oil and Gas Database Management

Survey Well Database Management System, *Lecouris, Yeko* The development of the CONQuEST Survey-wide well data management system continued with the design and programming of 22 additional computer programs totaling over 19,000 lines of "C" code. Final system documentation and first drafts of user documentation were completed for all production programs. The CONQuEST system now handles Oil and Gas permits, workovers, mail, and historical wells. In addition the system handles water well permits, completion reports and well records. The prototype programs are in production use within the Geological Records Unit.

• Oil and gas records usage The entire permitting database system was transferred from the Prime Info System to the new Oracle system. A personal computer prototype was developed and now replaces the Prime system.

• Water records usage A water well data entry program was developed using PC/Oracle to support the Geological Records Unit water well task force. This software was installed and is being used by the Water Well Task Force.

• Historical well data entry An oil and gas well data entry program was developed using PC/Oracle to support a contract effort to enter pre-1915 oil and gas data. This software was installed and is in use.

Oil and Gas Database Historical Data Addition, *Helm, Junkins, Lecouris, Yeko* A contract sponsored by Marathon Oil Company was approved to create a computer database of historical (pre-1915) oil and gas wells drilled in Lawrence and Crawford Counties. Three programs, totaling 2,000 lines of "C" code were developed and 7,400 wells were entered into the database. This software was added into the CONQUeST system.

Petroleum Information (PI) Database Validation, *Alinger, Lecouris, Yeko* Twenty-six Prime-Fortran programs were written to computer-match location information from the PI Oil and Gas database (40,199 wells) inhouse oil and gas databases. Manual matching of some 4,000 wells was performed to resolve mismatched location data. More than 13,000 PI historical wells were assigned Survey identification numbers. Summary reports of data-type and numbers were produced.

A design was completed for incorporation of this data into the CONQuEST system, and several preliminary "C" programs were written as the data transfer was begun. After transfer has been completed, validation of geological data (formation tops, elevations, casing data, available logs, and header data) will begin.

OTHER ENERGY SOURCES

Coal Bed Methane, *Damberger* Methane is being produced from coal beds in Alabama and New Mexico, and considerable interest exists in this potentially very large resource for natural gas. Several requests for information, mostly by consultants for investor groups, on the occurrence of methane in Illinois coal beds were handled during the year. Illinois State Geological Survey information is limited to analyses of coal samples from several drill holes. One of the drill holes was sampled and analyzed by Survey staff; the report on this drill hole summarizes all factual information available on the gas content of Illinois coals.

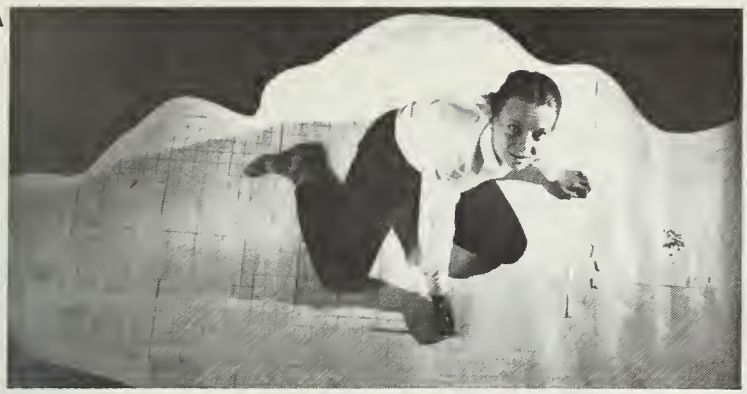
Geothermal Energy Resources of Illinois, *Larson* Thermal energy storage by means of ground-coupled heat pumps and ground-water heat pumps is an emerging technology now being used in Illinois to provide increased efficiency in residential and commercial space heating and cooling. A new methodology for mapping favorable areas for thermal energy storage systems was developed at the Survey and preliminary results are now available.

GROUNDWATER RESOURCES

The groundwater resources research effort in the past year has focused mainly on two studies funded by the Illinois Department of Energy and Natural Resources (ENR). These two projects, part of the ENR Aquifer Assessment program, will be finished early in FY90. The first project, a 3-year investigation, will result in three reports on the groundwater geology of the area. The second project is a 1-year study to better define the locations of bedrock valleys throughout the state. Bedrock valleys in some locations can contain sand and gravel aquifers. Mapping these valleys will result in new maps of bedrock topography and drift thickness.

In addition to these state-funded projects, water resource investigations are conducted under the sponsorship of local governments. A series of studies conducted for Kane County, including several individual municipalities, focused on adapting or developing techniques suitable for locating groundwater supplies in their areas. These studies involved the use of geophysical exploration techniques and provided locations for test drilling for water supplies; the Illinois State Water Survey handled the test drilling portions of the projects to validate predictions. The research on the Kane County studies is complete, and final reports are in preparation. A similar project for the City of Bloomington was recently approved and will be conducted in FY90.

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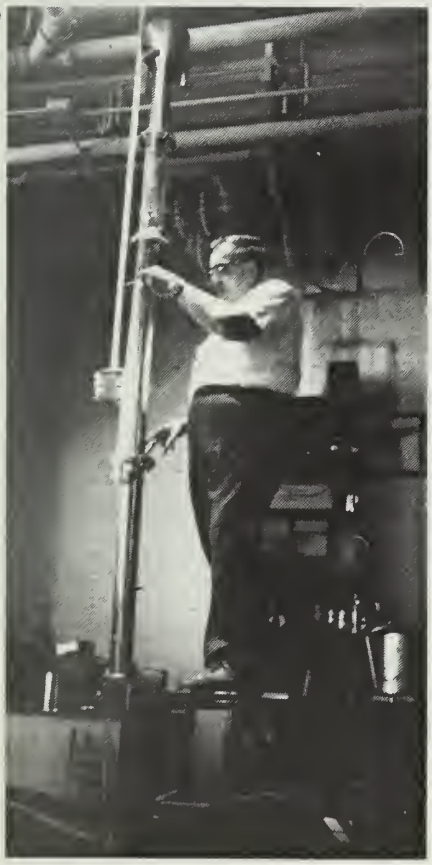
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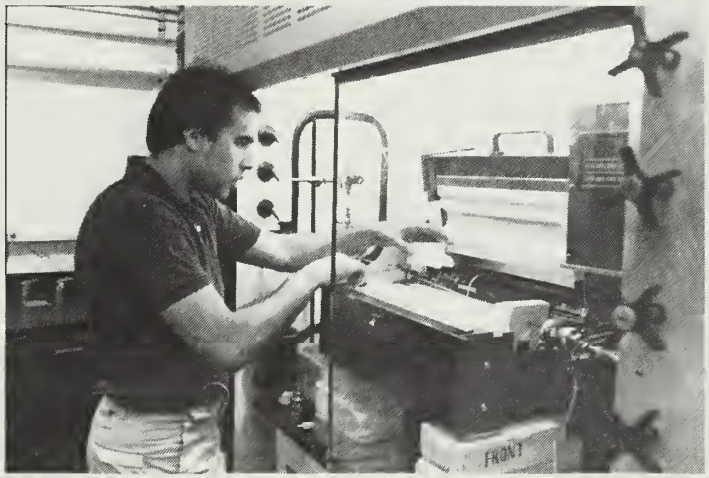
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(A) Geologist Cheri Chenoweth of the Groundwater Protection Section draws bedrock depth contours on a preliminary bedrock topography map; when completed, the map will provide detailed data useful in locating bedrock valley acquifers. (B) Assistant geochemist Suchada Broeren works in the newly remodeled microbial biology laboratory on a project to isolate and identify microbiological by-products that can enhance physical desulfurization of Illinois coals. (C) Geologist Donald Mikulic, Industrial Minerals and Metals Section, examines rocks at Thornton Quarry as part of a project to locate sources of aggregates for the Chicago metropolitan area. (D) Minerals engineer Henry Ehrlinger checks the column flotation machine, which removes ash and pyrite from coal; results obtained with this machine will be compared with results obtained from a conventional flotation machine. (E) Geologist Daniel Adomaitis, Geochemistry Section, puts a thermocouple in the tube furnace used in the carbon monoxide-ethanol desulfurization project.

The service work load in Groundwater Resources has remained at approximately the same level as last year.

Groundwater Assessments

Groundwater Resources in Kane County, *McFadden, Wegscheid, Seaber, Curry* An extensive inventory of groundwater resources in the glacial drift and shallow bedrock of Kane County has been supported by funds from the county and local municipalities. The project identified methods for locating aquifers with large potential groundwater supplies, and encouraged several communities to make separate contracts with the Geological and Water Surveys to further evaluate the methods in order to assess the potential for groundwater resources. The final report for this project, along with reports for Aurora, Geneva, Batavia, and the Fox River Valley, are in the Survey review process. A report for the village of Montgomery was published this spring.

Shallow Groundwater Resources in the Vicinity of St. Charles, Kane County, *Morse, McFadden, Orozco, Cheryl Wegscheid, Cantwell* The City of St. Charles contracted with the Illinois State Geological and Water Surveys to conduct a detailed investigation of the shallow groundwater in the immediate vicinity of the city. The investigation included surficial geophysical surveys (seismic and resistivity) and downhole geophysical logging of new and old test wells. The project identified potential groundwater resources and recommended locations for test drilling. Maps of these resources have been completed; the final report is in preparation.

Hydrogeologic Investigations for a Supplemental Groundwater Supply for the Cities of Normal and Bloomington, Illinois, *Kemptom, Vaiden* Farnsworth and Wylie, Consulting Engineers, requested assistance from the Survey in their continuing efforts to help the City of Normal find supplemental water supplies. A proposal submitted in July was approved by Normal in August for the period July 1 to December 31, 1988. The late start of the project required requesting and receiving an extension through March 1989. A draft report was submitted in March 1989.

A report recommending geophysical investigations was prepared for Farnsworth and Wylie (representing the City of Bloomington) in its efforts to locate supplies north of Normal to augment limited supplies of surface water.

Geophysical Surveys to Locate a Potential Supplemental Water Supply for Bloomington, Illinois, *Herzog, Larson, Heigold* The City of Bloomington obtains its water supply from two reservoirs, Lake Bloomington and Lake Evergreen, located north of the city. Water levels in these reservoirs have dropped sharply, causing water shortages and restrictions beginning in the summer of 1988. The Survey contracted with Bloomington in June 1989 to explore for groundwater resources to provide a supplemental water supply in the city. Field studies were scheduled to begin in July 1989.

Regional Assessment of Northern Illinois Groundwater Resources, *Seaber, Avery (United States Geological Survey), McFadden, Holden, Cantwell, Morse, Stone, Orozco, Wegscheid* This project funded by the Illinois Department of Energy and Natural Resources is a 3-year review and investigation of groundwater resources in the northern 35 counties of Illinois. Identification of potential groundwater resources will be useful to planners interested in new or increased water supplies. Base maps for the area were completed in February. Entry of well-log data into a computerized database was completed in June. Draft maps of bedrock topography, drift thickness, and sand and gravel were completed in late June. The final contouring of draft maps was scheduled for July.

Groundwater Resources in Bedrock Valley Aquifers, *Seaber, Avery (United States Geological Survey), McFadden, Chenoweth, Orozco, Wegscheid, Cantwell* This project, which covers the entire state, was designed to better define valleys in the bedrock surface and to determine whether the valley-fill deposits may provide groundwater resources. Bedrock valleys can be

important sources of groundwater in scattered locations throughout the state. Base maps have been prepared and data is being entered into a computerized database.

Interpretation of Geothermal Surveys to Detect Aquifers, *Larson* Geothermal prospecting for groundwater, a method utilizing small variations in ground temperature to locate shallow aquifers, was conceived by Survey scientists in the 1960s. A new, computerized interpretation method for this prospecting tool was developed to make the method more practical. One- and two-dimensional models have demonstrated that the theory is correct. A final report, in the form of a doctoral dissertation, is near completion.

Mapping of Underground Sources of Drinking Water, *Seaber, Poole, Waldeck, Hwang, Helm, Pool* The first phase of this project, funded by the Illinois Department of Mines and Minerals (DMM) and the U.S. Environmental Projection Agency was completed in November 1988. Contoured maps and cross sections were produced to illustrate the distribution of groundwater in the pilot area (Clay County) having estimated total dissolved solids concentrations of less than 3000 mg/L, between 3000 and 10,000 mg/L, and greater than 10,000 mg/L. Data used in producing the maps were entered into a database on the Prime 9955. This pilot study helped determine the methodology to be used in other counties in determining the depths for each of these concentrations. The DMM needs this information to regulate the underground injection of oil field brines so as to protect the state's groundwater supplies.

Delineation of Underground Sources of Drinking Water, *Seaber, Poole, Waldeck, Chillson, Helm, Pool* This second phase of the "Mapping of Underground Sources of Drinking Water" project began in November 1988 and was completed in April 1989. The project was funded by the Illinois Environmental Protection Agency, Division of Public Water Supplies. Contoured maps were produced to show the distribution of groundwater in Crawford, Lawrence, and Wabash Counties having estimated total dissolved solids concentrations of less than 3000 mg/L, between 3000 and 10,000 mg/L, and greater than 10,000 mg/L. Data used to produce the maps were entered into a database on the Prime 9955. East-west and north-south cross sections illustrating the relationship between stratigraphy and estimated water quality were prepared for each of the three counties.

Water Use

Geophysical Study of Shallow Groundwater Geology in Kankakee and Northern Iroquois Counties, *McFadden, Morse, Orozco, E. Smith, Wegscheid* Farmers in eastern and northern Iroquois Counties have increased their use of groundwater for irrigation, causing seasonally declining water levels in the shallow dolomite bedrock aquifer and problems in some local wells. These problems accented the need to acquire more information about the shallow hydrogeology of the area, particularly the long-term effects of continued large withdrawals.

Geophysical methods were used for hydrogeologic mapping in this complex area: seismic refraction to map the bedrock surface, electrical earth resistivity surveys and borehole geophysical surveys to acquire new information to supplement data from existing well records on the nature of the glacial drift. The final report is in review. This report will be useful in addressing complaints filed under the Water Use Act.

Water Use Act Activities, *E. Smith, Seaber, Wegscheid, Cantwell* Under the provisions of the Water Use Act of 1983, the Illinois State Geological Survey and State Water Survey provide technical assistance to the staffs of county Soil and Water Conservation Districts (SWCD) by assessing the potential impacts of large-capacity water wells on groundwater resources. Two regional reports for Kankakee County were completed. During this period, Survey staff evaluated 90 well sites to determine hydrogeologic conditions in the area surrounding the well sites. Of the sites evaluated during this period, 37 required full geologic reports by Survey staff; an additional 32 sites are under review and will require full reports.

Under the 1987 amendments of the Water Use Act, both Surveys provide technical assistance to the county Soil and Water Conservation Districts of Kankakee, Iroquois, McLean, and Tazewell Counties in the resolution of complaints received regarding the loss of water supply to wells in the vicinity of large-capacity water wells. During this period Survey staff reviewed 107 sites, resolved 116 complaints of water loss due to high-capacity wells, and reviewed 70 reports of investigation furnished by the Illinois State Water Survey.

Technical Assistance

Service Geophysics-Electrical Earth Resistivity Surveys, *Reed* Electrical earth resistivity surveys are useful for interpreting the sequence of shallow water-bearing earth materials. Surveys were conducted at 52 sites, including 6 municipal sites, 1 subdivision, 14 farms, and 31 private acreages. Resistivity surveys are performed at problem locations where test drilling failed to obtain an adequate groundwater supply.

Service Requests for Groundwater and Geologic Information, *Brower, Reed, Morse, Poole, Smith* Requests for information were received from well drillers, farmers, citizens, industries, and governmental agencies desiring to locate, develop, use and evaluate groundwater resources. Survey staff prepared 171 groundwater possibilities reports, responded to more than 1500 phone calls, 90 letters, and 97 office visits, and conducting three sieve analyses for municipalities.

Borehole Logging, *Reed, Morse* Borehole logging provides graphs of the chemical and physical characteristics of water-bearing earth materials. Borehole logs, including resistivity logs, are used for correlation of aquifers between wells, aquifer evaluation, and analysis of unconsolidated and consolidated zones. Log data are also frequently coordinated with seismic data to compile a three-dimensional picture of site geology. This year 57 borehole logs were run in ten counties.

INDUSTRIAL MINERALS AND METALS

Illinois, with coal reserves amounting to billions of tons and significant oil production, is a major producer of energy-related minerals. The importance of these commodities to continued industrial development is widely recognized, but the present and future significance of the state's industrial minerals—including fluorite, limestone, dolostone, sand and gravel, barite, sandstone, tripoli, clay and shale, is not fully appreciated. These commodities and their products are used in construction, manufacturing, agriculture, and chemical processes. They are the essential components of the Illinois infrastructure; its buildings, sewers, bridges and highways.

Historically, the Illinois State Geological Survey has engaged in research and provided information on industrial mineral resources to industry, other state and federal agencies, landowners, and the general public. There is a continuing need for studies on the location, characterization, mode of origin and potential uses of industrial mineral and metal commodities which will play an important role in rebuilding the infrastructure required for progress in the 21st century. The Survey, with a minimum program, is continuing decades of prominent contribution in the field of industrial minerals. Recent projects reflect new emphasis on regional resource assessment, response to environmental problems, and mineral processing.

Mineral Resource Assessments

Paducah CUSMAP, *Eidel (coordinator), staff* An evaluation of the mineral resource potential of the Paducah 1° x 2° quadrangle (Kentucky, Illinois, Indiana, Missouri) is being conducted by the United States Geological Survey (USGS) as part of the Conterminous U.S. Mineral Assessment Program (CUSMAP), with the cooperation of the four states. Objectives are to compile all existing useful geological, geophysical, and geochemical data; identify and acquire needed new information to fill gaps in the database; and complete an in-depth evaluation of the fluorspar, barite, base metal, beryllium, thorium, rare earth, industrial minerals, oil and gas, and coal potential of the Paducah quadrangle. The Paducah Project, planned as a 4-year study, is scheduled for

completion September 30, 1990, but is running behind schedule because of staffing problems at both federal and state levels. During FY89, progress was made on the following tasks:

• **Cross Sections of the Sauk Sequence in the Paducah CUSMAP Area, Southern Illinois Basin,** *Sargent, Whitaker, Treworgy* Detailed cross sections of the Sauk Sequence in the CUSMAP area of Illinois, Indiana, Kentucky, and Missouri are being prepared to evaluate the potential for mineral resources. Hydrothermal mineralization is known to occur in the eastern part of the CUSMAP area and just west of the area in southeastern Missouri. Geophysical logs of the deep wells in the area have been digitized to permit computer generation of the final product. Completion of these cross sections is expected by January 1, 1990.

• **Insoluble Residue Study,** *Baxter, Masters, Eidel; R. and S. Erickson, Goldhaber (USGS)* In FY89, 1229 samples representing about 24,665 feet of limestone/dolomite were collected from the Geological Samples Library and shipped to the Denver Federal Center for acid digestion and analysis.

• **Heavy Mineral Study,** *Masters, Dreher, Baxter, Eidel, Mosier, Goldhaber (USGS)* The Illinois State Geological Survey and the USGS are cooperating in a study of the geochemistry of the Mt. Simon (La Motte) Sandstone and its role as a passageway for mineralizing fluids. The Survey is carrying out a study of the heavy minerals collected by bromoform and panned separations from samples taken from wells in the Illinois. Identification of the minerals will assist in the differentiation of epigenetic elemental and mineral suites from those from detrital sources.

• **Mines and Prospects,** *Baxter; Johnson (USGS)* A map and a database providing locations and information for all known mines and prospects in Illinois are being prepared, using Survey files, the U.S. Bureau of Mines MILS listings of mines and prospects, and the USGS MODS listings prepared previously for the Strategic and Critical Minerals program. The Survey began compilation of all available location data on 7.5-minute quadrangle maps (1:24,000) along with descriptive information for each locality. This compilation is scheduled for completion by October 1, 1989. The maps will be digitized and descriptive information encoded by the USGS.

• **Coal Resource Maps,** *C. Treworgy, Bargh, Damberger* The coal resource maps provided by the Kentucky Geological Survey were digitized and added to our database. New coal crop line data generated during the COGEOMAP large-scale geologic mapping were also digitized.

• **Clay Resource Map,** *Hughes, Moore* A map of actual and potential clay resources will be prepared from geological maps of the Paducah region. Resource potential evaluation will follow the methods used in Missouri for an earlier CUSMAP effort.

• **Bedrock Geologic Map,** *Nelson* The Paducah quadrangle has been divided into four 30- by 60-minute quadrants at a scale of 1:100,000: West Frankfort (NE), Paducah (SE), Carbondale (NW), and Cape Girardeau (SW). Bedrock geologic maps, stratigraphic columns, cross sections, and descriptive texts were prepared for each. All were technically reviewed inhouse and outside the Survey and necessary revisions were made following review.

• **CUSMAP Surficial Geologic Mapping of the Paducah Quadrangle,** *Berg* The surficial geologic map for the Paducah Quadrangle CUSMAP project is nearly complete. Additional field checking was conducted to verify the units shown on the existing stack-unit map of the area as well as those which appear on the surficial geologic map. Significant modifications of the maps were made in areas adjacent to the Cache River valley and in several areas of lacustrine deposits adjacent to rivers tributary to the Wabash. These changes will be digitized into the recently completed stack-unit map digitized computer file, which is part of the Survey's Geographic Information System. The Survey's final products will be a digitized stack-unit map and a surficial geologic map of the Paducah Quadrangle.

• **Digital Databases for the CUSMAP Project Area,** *Pool, McKay* The Survey has received from the USGS the 1:100,000-scale Digital Line Graph series of data for the entire Paducah Quadrangle. These data include all the lines typically shown on a 7.5-minute quadrangle, including streams, roads, public land surveys, and hypsography. The data are currently being converted to the ARC/INFO format for use on the Geographical Information System.

• **Midcontinent Strategic and Critical Minerals Program (MSCMP),** *Baxter, Kolata, Sargent, Maynor, J. Treworgy, Hageman, Eidel* The MSCMP, an ongoing USGS project involving cooperation with 12 states, is designed to assess the mineral potential of shallow basement and sedimentary sequences in the midcontinent area. Special emphasis has been placed on the potential for carbonate hosted metallic deposits. During FY 89 a series of maps for the state of Illinois was prepared showing the thickness and limestone\dolomite ratios of the Bonneterre/Eau Claire and Ottawa carbonates (scale, 1:1,000,000), and a series of four east-west cross sections, depicting vertical and lateral changes in the Valmeyeran (Middle Mississippian) limestones.

Limestone and Dolomite Resources

Aggregate Resource Analysis, Northeastern Illinois, *Mikulic* The production of aggregate for construction is a major industry in the Chicago Metropolitan area. In recent years the depletion of known resources and urban encroachment on undeveloped sites have resulted in an uncertain future for the aggregate industry. Since 1970, seven of 20 quarry sites in the Chicago Metropolitan area have been abandoned and only four of the remaining sites have room for any significant lateral expansion. The goals of this project are to identify additional local sources of aggregate and help quarry operators fully utilize existing resources through a better understanding of the local geology. During the past year, 39 requests for information made by quarry operators have been answered by Survey staff. Existing quarries and exposures have been studied along with subsurface cores to provide a comprehensive database on the geology of the study area.

Inventory of Active and Abandoned Quarry Sites in Cook County, *Mikulic* The lengthy history of quarry operations in Cook County has not been well documented in the past. Many individual quarry sites have been abandoned, filled, and forgotten. The purpose of this project is to provide an inventory of all active and abandoned quarry sites in Cook County and determine their location, size, depth, history, and geological features. This information is now being compiled, and detailed maps of individual sites will be constructed. These data will be useful in locating new quarries, making plans (short-term and long-term) for existing quarries, investigating potential environmental problems related to abandoned sites, and increasing understanding of local geology. An extensive search for, and study of, historical documents during the reporting period has allowed development of a more detailed understanding of individual quarry sites and provided an essential database for geological analysis. This database has already provided data essential for planning to one state agency and a corporation.

Possible Underground Mining of Dolomite in Central Illinois, *Baxter* Counties in Central Illinois have little or no production of either limestone or dolomite for use as aggregate in portland cement and bituminous mixtures. The area with little quarriable rock includes major down-state metropolitan areas: Champaign-Urbana, Springfield, Decatur, Peoria, and Bloomington-Normal. A possible source of high- quality stone for these uses exists in the relatively deep subsurface in this region. A report on this subject, completed during an earlier period, will be included in the Proceedings of the 23rd Forum on the Geology of Industrial Minerals, to be published by the Illinois State Geological Survey. Possible targets for underground mining in central Illinois are carbonate rocks of the Ste. Genevieve-St. Louis and Burlington Limestones, the Devonian-Silurian Hunton Megagroup, and the Galena Group.

Effect of Different Kinds of Rock in Illinois Gravels on Freeze-Thaw Test Beams, *Masters* This paper, based on research completed and reported earlier, will be published in the Proceedings of the 23rd Forum on the Geology of Industrial Minerals. The study identified various

categories of rock types that appear to be susceptible to freeze-thaw deterioration in Illinois highways and suggested that porous types of chert were the major cause of the deterioration.

Clay Resources

Clay Mineral Business, *Hughes, Moore, White, Krumm, Taylor* Support of clay-mineral-based industrial activity in Illinois included a number of consultations, analysis of samples, phone conversations, and the assembling and sending of operation-related data. Specific examples included (1) completion of a report covering Bond, Clinton, Madison, Monroe, Randolph, St. Clair, and Washington Counties at the request of the Southwestern Illinois Planning Commission (SWIMPAC) in support of their efforts to attract a brick and tile manufacturer; (2) analysis of samples from Pope and Hardin Counties for parties interested in selling kaolin or producing clay products from their kaolins, and review of a proposal for exploration for kaolins in nearby federal forest lands; (3) compilation of information on the best sites for a new plant in Illinois for a major eastern U.S. brick producer; and (4) preparation of a review of the history, geology, and potential of Illinois clay businesses for the Proceedings of 23rd Forum on the Geology of Industrial Minerals.

Alteration of Clay Minerals from Shale of the Davis Formation, Southeast Missouri, *Panno* The objective of this research is to evaluate the alteration of clay minerals extracted from shale overlying an ore deposit of the Mississippi Valley type. Shale samples have been collected, clay minerals separated from the samples, and analyzed by X-ray diffraction. Preliminary results indicated that certain clay and other minerals may be present in samples near the ore zone and absent in samples from more than 1 to 2 miles from the ore zone. The data may be useful in the exploration for ore deposits of the same type in Illinois.

Kaolin from Plant Waste Streams, *Ehrlinger, Khan, Hughes, Baxter, Masters* Work has continued on the beneficiation of the waste streams from the silica producers of North Central Illinois. For many years these streams containing kaolin clay and silica sand have been impounded near the operating plants. Previous work showed that the sand and clay can be separated into two salable products.

Samples of the waste streams were collected over a period of time long enough to ensure that the samples would be representative of the waste from current production. The samples were treated in a cyclone from which the clay and sand were separated. The clay meets or exceeds the standards for several types of clays that could have a value of approximately $64 per ton. The sand from the separation is a typically clean, round-grain, fine sand of the type normally associated with the St. Peter sandstone formation.

Large amounts of this waste are available. The major producers have been impounding significant tonnages of the waste material for a number of years.

Fluorspar and Metal Resources

Intrusive Breccias at Hicks Dome, Hardin County, Illinois, *Bradbury, Baxter* Intrusive breccias at Hicks Dome are believed to have been formed by explosive release of gases from a deeply buried alkalic magma, an agency also responsible for the approximately 4,000 feet of uplift related to the dome. Approximately 45 breccias bodies have been mapped in the immediate vicinity of Hicks Dome. Most are nearly vertical dikes up the 10 feet wide, and some are bodies of undetermined shape. Some breccia exposures are weakly mineralized. Mineralized breccia (F, Pb, Zn, Ba, Nb, Be, Ti, Th, and REE) is known to occur at depth. A report describing the physical and chemical character of Hick Dome breccias, related mineralization, and their modes of origin is now being revised in response to internal peer review. The authors anticipate that the manuscript will be ready for technical editing in the fall of 1989.

Beneficiation/Processing

Design and Construction of a Computerized Grinding Mill, *Khan, Baxter, Shop Staff; Gurmen, (University of Illinois)* Millions of tons of industrial mineral resources and ores of metals are

ground annually in preparation for further processing and/or for end use. Size reduction operations are one of the most cost-intensive steps of the processing operations and are notoriously inefficient in utilizing energy. Small improvement in the grinding efficiency of the existing systems would lead to significant energy and cost savings. A laboratory-scale computerized tumbling rod/ball mill was designed and constructed to test controls required for optimization, provide better understanding of the fundamentals of the comminution process, and test the impact of changes in the design of the mill and lining on energy consumption.

A computer connected to the control through an analog digital convertor monitors the signals from the mill. The torque, speed, temperature, noise level, and frequency are measured by appropriate sensors and the signals are transmitted to a computer through an analog digital convertor for evaluation, storage, and control. A parametric study will be conducted and evaluated.

Technology Transfer and Information Services

28th International Geological Congress (IGC) Field trip, "Precambrian and Paleozoic Geology and Ore Deposits of the Midcontinent Region (USA): IGC Fieldtrip T147, *Baxter, Bradbury* A guidebook covering the Illinois portion of the trip was published and made available at the meeting. The comprehensive manuscript, prepared and peer-reviewed at the Survey, discusses the sedimentary and igneous rocks, the stratigraphic and structural setting, and the mineral deposits of the fluorspar district and includes descriptions of stops in Illinois and Kentucky. The volume will be part of a comprehensive set of IGC publications available in libraries around the world.

Industrial Minerals Publications (IMNs) of the Illinois State Geological Survey, *Goodwin, Mikulic, Baxter* The purpose of this project is to revise, update, and expand IMN 69, a published, lightly annotated list of Survey publications related to the industrial and metallic minerals of Illinois. Timing of this publication is scheduled so that it will be available when IMN 69 becomes out of print, probably in 1990. The revised list, arranged by commodity, has been updated.

Industry Exploration Activities in Illinois—1988, *Baxter, Damberger, Hughes* The Survey provides a brief resume of industry exploration activities for the annual review issue of *Mining Engineering*, a monthly periodical published by the Society of Mining, Metallurgy and Exploration (SME, formerly Society of Mining Engineers). Illinois exploration during the calendar year 1988, including activities related to such diverse commodities as coal, fluorspar, crushed stone, natural sands and gravels, tripoli, and clays, were summarized for publication in the May issue of *Mining Engineering*.

Minerals of Illinois, *Baxter* Agronomy clubs from universities comprising Region 4 were hosted by the Field and Furrow Club at the University of Illinois in April. An illustrated talk featuring those minerals of special economic importance to agriculture and other related industries of Illinois was presented upon invitation from the student committee.

MINERAL ECONOMICS

Market Research

An Evaluation of the Markets for Byproducts of the Carbon Monoxide-Ethanol Desulfurization Process, *Schaschwary, Bhagwat* As part of this research supported by the Illinois Department of Energy and Natural Resources, the demand and supply of four process byproducts were studied: acetaldehyde, sulfur, hydrogen sulfide, and carbonyl sulfide. Only acetaldehyde and sulfur were found to have significant demand on an industrial scale.

Acetaldehyde, which would be produced in large quantities in the desulfurization process, faces price competition from substitute substances produced from petroleum or natural gas. Acetaldehyde is used in the production of acetic acid. The demand for acetic acid has been increasing at an annual rate of about 2 percent. Acetaldehyde from the CO-ethanol process must

first recapture the acetic acid market. In the long run there is hope that alternative uses of acetaldehyde would be developed, especially as a road de-icing agent substituting for common salt. In addition, the cost savings from averted corrosion and environmental damages represent a major economic incentive to be considered when assessing the future market potential for acetaldehyde.

Sulfur has a much larger world market than acetaldehyde. Sulfuric acid produced from sulfur is a major component in fertilizer production. Sulfur from the CO-ethanol process should not therefore easily saturate the market. The final report on market prospects for CO-ethanol byproducts was completed in September 1988.

Economics of the Carbon Monoxide-Ethanol Coal Desulfurization Process, *Schaschwary, Bhagwat* A major objective of the study was to assist the engineers in design modifications that would lead to cost savings. Another purpose of this study was to determine the break even prices of all the products of the CO-ethanol process (i.e., acetaldehyde, sulfur and desulfurized coal). A conceptual process flow diagram with estimated input-output data was used to conduct a preliminary economic study. Results available as of June 1989 indicate that a 1,000 tons-per-day coal processing plant could require a $156 million to $212 million investment. Substantial design modifications with the aim of reducing initial investments are recommended. Collection of detailed engineering data would have to precede such a design change.

Strategic and Critical Minerals: What Are They? Who Needs Them? *Bhagwat, Eidel* Strategic and critical minerals have traditionally been closely associated with the nation's defense needs. The U.S. national defense stockpile involves more than 90 minerals and materials valued at about $10 billion. The stockpile commodities are currently determined by government agencies in the Departments of Defense, Commerce, and Interior. The stockpiling does not appear to adequately consider the principles of "supply vulnerability" and therefore contains too many commodities and costs more than it should. Careful application of the vulnerability criteria indicated that only about a dozen minerals could be truly classified as strategic and/or critical. Four minerals—chromium, cobalt, manganese and platinum group metals—are the most strategic minerals. Titanium, tungsten, diamonds, and graphite are also critical, though to a lesser extent.

Extraction Research

Secondary Recovery of Coal Fines: An Environmental and Economic Cost/benefit Analysis, *Bhagwat, Baxter, Khan, Curran, Rice* Under a grant from the Illinois Department of Energy and Natural Resources (ENR) research was completed over a 12-month period on the technical and economic feasibility of recovering fine coal currently being discarded by coal cleaning plants. An estimated 6 to 8 million tons of fine material containing an average of about 50 percent coal are deposited annually in slurry ponds in Illinois. Recovery of coal from the fine material would not only reduce the waste amount but also would improve the environment. Samples of fine material from three sites representing major coal seams, major coal-producing counties, and the mining and coal-cleaning technologies used in the state were analyzed. Results indicate that simple physical cleaning of fines having a particle size larger than 106 microns is feasible, using cyclones, spirals, and centrifuges. Physicochemical methods such as froth flotation would be required to recover coal from particles smaller than 106 microns. It was also found that the particle-size barrier between physical and physicochemical methods was flexible and could be varied if economic conditions require it. Three alternative flow diagrams for the recovery of coal were designed. The economic feasibility was calculated using the Net Present Value (NPV) analysis method. Results indicated that in all three cases, the NPV was positive: the fine-coal recovery process would pay for itself under current cost/price conditions.

A major objective of the work was also to offer a tool to the operators to enable them to determine the economic feasibility of the process, given their own specific conditions. A computer model was developed that can be used interactively by operators having little prior knowledge of computers. The results indicate that fine wastes with a coal content as low as 11 to 13 percent

could be economically recovered, and land savings could potentially be as high as 20 to 30 acres per year. The final report was submitted to ENR in September 1988.

Technology Transfer and Information Services

Mineral Economics Course for Engineering Students at the University of Illinois, Urbana/Champaign, *Bhagwat* The Department of Material Science and Engineering has reappointed Subhash Bhagwat as Adjunct Professor for the fall semester 1989 to teach a course in Mineral Economics (MIN E 302). The course manuscript developed in the 1988 teaching session is being substantially expanded to accommodate additional topics.

Illinois Mineral Industry in 1987 and a Review of Preliminary Production Data for 1988, *Samson, Bhagwat* Final 1987 data show a slight decline in the value of Illinois mineral production from about $2.656 billion in 1986 to $2.621 billion in 1987. Oil production dropped by nearly 12 percent, coal by 4 percent, and gas by 27 percent. Oil prices increased to an average of about $17.50 per barrel in 1987 from $14.70 in 1986, but could not prevent the production decline. Prices of coal also showed a softening from $30.00 per ton in 1986 to $29.60 per ton in 1987, reflecting a soft in-state coal market caused by increased production of nuclear electricity. Sand and gravel, and stone production increased by 1.6 percent and 17.9 percent, respectively, over the previous year. Average prices also creased by about 10 percent for sand and gravel and about 2 percent for stone.

Preliminary 1988 data indicate a further sharp decline in fossil fuels and a continued improvement in the industrial minerals areas. Coal production declined by about 7 percent and coal prices softened further to $29.00 per ton. The decline is attributable to continued increase in nuclear electricity generation. Oil production in 1988 is estimated to have been about 22.5 million barrels (6.7 percent lower than in 1987), and prices declined to near 1986 levels ($14.80 per barrel). Sand and gravel production in 1988 was up 9.5 percent to about 31 million tons, and stone production was up by 4.2 percent, to 54.3 million tons. Total value of minerals produced in Illinois was down 8.5 percent in 1988 to about $2.4 billion.

Directory of Mineral Producers in Illinois, *Samson, Masters* The directory provides a ready reference to producer names, locations, and addresses and to their major products. The directory was thoroughly revised and updated this year, and is being prepared for publication. Questionnaires were sent to verify the existence and addresses of producers reported to be operating. The replies to questionnaires and the personal knowledge of Survey staff were used to produce a new directory that will reflect the industry much more accurately than before.

Environmental Geology and Geochemistry Research and Service









(A) Coastal geologist Michael Chrzastowski (center) and two members of the U.S. Geological Survey prepare to move a bottom sampler used to collect sediments in Lake Michigan near Evanston. (B) Three Survey geologists (from left), John Kempton, Donald McKay, and Brian Trask, conduct a field briefing for Champaign County officials and members of the public. The three are among several staff members assisting the county in its efforts to locate landfill sites. (C) Keros Cartwright, head of the Hydrogeology Research Laboratory, adjusts suction-vacuum lysimeters that monitor moisture movement in the experimental landfill soil liner being tested at the laboratory. (D) Donald Keefer (left), geologist in the Groundwater Protection Section, and Richard Berg, acting head of the section, examine a newly completed map of recharge areas of Illinois. The map and other data will be used to identify areas with high potential for groundwater contamination.

ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY RESEARCH AND SERVICE

The Environmental Geology Program develops and interprets basic geologic data that can help government, industry, and the public make informed decisions and take appropriate actions to protect and enhance the natural environment and wisely develop the state's mineral resources. Program research and service focus on locating and protecting groundwater resources, managing wastes, siting facilities in Illinois, monitoring lakes and rivers, conducting land-use planning studies, and studying natural and manmade geologic hazards (such as landslides, earthquakes, and mine subsidence) and suggesting ways to mitigate their effects.

ENVIRONMENTAL STUDIES AND ASSESSMENT

The Environmental Studies and Assessment program functions to help industry, institutions, and government agencies locate and assess suitable sites for facilities in Illinois, carry out environmental impact studies, and identify cost-effective mitigation procedures in siting efforts. In the past year, emphasis was placed on three projects. The first was a geologic study of a site at Argonne National Laboratory for the planned 7-GeV Advanced Photon Source, a $300 million synchrotron. The second project consisted of "wrap-up" efforts for siting the Superconducting Super Collider (SSC) in Illinois. The third major effort was a continuation of aid to the Office of Surface Mining and the Illinois Department of Mines and Minerals in constructing databases for the Lands Unsuitable for Mining Program and the mine permit process. Studies also were conducted to determine long-term impacts of human activities on major Illinois lakes and streams.

Special Siting Studies

Geotechnical Site Investigation, 7-GeV Advanced Photon Source, Argonne National Laboratory, *Killey, Trask, Su, DuMontelle, others* Survey geologists obtained a continuous record of water levels on one piezometer and weekly levels on nine other piezometers installed on the site on which the experiment hall/positron storage ring will be constructed. These data, from three different lithologic units, permit description of variations in the hydrologic characteristics of these units. The potentiometric surface of the confined bedrock aquifer slopes to the north as a result of pumping by Argonne National Laboratory for its water supply. The water table in the uppermost lithologic unit, a silty clay till, slopes to the northwest. Within this till, a widespread water-laid deposit, mostly sand, forms a confined aquifer with the potentiometric head sloping westward. Pressures in this sand are such that precautions must be taken to prevent collapse when it is penetrated by drill holes for caissons, or when trenches are dug that may intersect unplugged drill holes. Water-level data and engineering tests show no problems that would preclude construction and successful operation of this facility, so long as normal engineering precautions are taken. For the architectural-engineering firm, Survey researchers also identified areas where further testing is needed.

A supplemental report on soil tests was completed. The soil testing program included Proctor compaction tests (both standard and modified), Atterberg limits determinations, specific gravity measurements, and consolidation tests. Survey test results were compared with results obtained by STS Consultants, Ltd. Suggestions were proposed for the next phase of geotechnical exploration. A meeting was held with APS representatives and consultants, Lester B. Knight & Associates, Inc., and Survey representatives. Soil-related issues for APS construction were discussed, particularly the plans for the experiment hall and storage ring foundation.

Results of this geotechnical investigation were presented in poster format at the annual meeting of the Association of Engineering Geologists in Kansas City in October 1988. Trask and Killey were invited to make a presentation on the investigation at the December meeting of the Illinois-Indiana section of the American Institute of Professional Geologists.

Superconducting Super Collider (SSC) Site Investigation, *SSC Task Force* The SSC site feasibility investigation conducted by the State of Illinois represented the most comprehensive and detailed scientific, social, and economic examination ever carried out by Illinois state government.

Following the choice of a Texas site, the State focused its final efforts on organizing the wealth of information obtained from the investigation into a usable format that would continue to benefit Illinois.

Redirection of the geological and environmental screening teams led to the completion and publication of 15 SSC "wrap-up" projects: senior administration and support services, curation of SSC files, Kane County geology for planning and water resource studies, area hydrogeologic summary, publication of information on use of the Geographic Information System for geological and environmental assessment, archiving and cataloging of SSC-related materials, geotechnical summaries, regional stratigraphic analysis, analysis of geophysical data, integration of well data, piezometer well maintenance and abandonment, plugging and monitoring of seismic shot holes and abandoned wells, sample and core preservation and cataloging, and summary of the Quaternary stratigraphy.

Research results can be applied to natural resource issues of northern Illinois, including regional planning, water supplies, and waste disposal. Geotechnical and groundwater data pertinent to plans for upgrading and expanding Fermi National Accelerator Laboratory will be published. Finally, the SSC files, reports, and publications will be properly archived for use in future projects.

All of the above tasks were considered complete as of June 30, 1989. Following are details regarding these efforts and the work carried out on the SSC Project during the year:

• **Geotechnical Summary of Drift/Bedrock Data from SSC Project,** *Bauer, Curry, Hasek* Large quantities of geotechnical data were collected as part of the SSC project. Some of this information was summarized in a geotechnical report attached to the Illinois proposal. The remaining data and full tables of the previously summarized data were assembled, interpreted, and discussed. The information will be beneficial to many types of siting and construction efforts associated with near-surface glacial materials and the deeper bedrock in northeastern Illinois.

• **High-Resolution Seismic Reflection Profiling and Shallow Seismic Refraction Profiling,** *Heigold* Both high-resolution seismic reflection and shallow seismic refraction surveys were made in northeastern Illinois to address specific problems associated with the construction of the proposed SSC. These surveys provided information on the lateral continuity of stratigraphic units and on their depths and configuration in the subsurface. This framework information is being used to define and address many geological, hydrological, and engineering problems in northeastern Illinois. For example, the data identified the need for a more detailed characterization of the unconsolidated materials above the bedrock to better understand the nature of the interface between the near-surface glacial deposits and bedrock surface. The high resolution seismic reflection surveying has proved to be a viable means of expanding knowledge of the structural and stratigraphic make-up of the region between discrete, deep drill holes. Information on the nature and lithology of the unconsolidated glacial deposits and bedrock surface and on the depth and configuration of that surface can be used in future construction proejcts and in the evaluation of the region's groundwater and aggregate resources.

• **Disposal Alternatives and Potential Uses for Material to be Excavated from the Proposed Site of the Superconducting Super Collider in Illinois,** *Curran, Masters, Bhagwat, Hindman* Construction of the SSC in a tunnel would have generated 4.6 million tons of excavated material, 94 percent of which would have been dolomite and dolomitic limestone. Five potential uses for that material were found: storage in sand and gravel pits and rock quarries, possibly for later uses; restoration of the Kaneville Esker; landscaping around SSC campus and service areas; use in local forest preserves; and use in local landfills. The available pits and quarries could accommodate all of the excavated material, and local aggregates operators indi- cated interest in accepting up to eight times the volume of material to be generated. All five options were evaluated as environmentally sound. A paper describing alternatives will be published as part of the Proceedings of the 24th Forum on the Geology of Industrial Minerals. A full report was published as Illinois State Geological Survey Environmental Geology Note 125.

• **Environmental Impact Statement for the SSC,** *Gross, Schneider, Kempton, the environmental screening and geological teams* In August 1988, the U.S. Department of Energy (DOE) published a Draft Environmental Impact Statement (DEIS) for the SSC. Because the ten-volume report contained many serious errors, especially with respect to groundwater issues, the Survey staff compiled several hundred technical comments and corrections. Those materials were compiled by Harza Engineering Co. and submitted to DOE in eight volumes. In October 1988, DOE held public hearings on the DEIS at each of the seven sites under consideration for the SSC. Leighton, Cartwright, Kempton, Bauer, and Gross testified for the Survey. All points raised by Survey geologists were corrected in the final EIS issued in December. That final EIS is a 22-volume, 8,800-page work. Seventeen thousand copies were printed and distributed by DOE.

• **Public Information on the SSC project and SSC site,** *Gross, Kempton, Etchison, Lach, others* Dozens of talks on the SSC were made to service clubs, civic groups, environmental groups, and other groups at various meetings at Fermi National Accelerator Laboratory (Fermilab) and in Chicago. Director Etchison and Gross visited editorial boards of 11 Chicago-area newspapers. Then in a series of one-day media tours to St. Louis, Columbus, Milwaukee, Indianapolis, and New York, a team visited newspaper editorial boards and other media. With a single exception, every visit resulted in editorials favorable to both the construction of the SSC and its placement in Illinois. The exception did not choose to report on the visit.

• **Geological Program to Site the SSC in Illinois,** *Leighton, Kempton, Gross, Bauer* At the 100th anniversary meeting of the Geological Survey of America in Denver, a special symposium examined the process of applying geological data to the siting of the SSC. Six of the seven states on the SSC Best Qualified List presented talks. The paper presented by the Illinois team is expected to result in a manuscript on the history of the SSC project.

• **SSC Archives,** *Krick, Wasson* Immediately after the announcement that Texas would be the SSC site, the archives staff began acquiring key SSC files and documents for Fermilab, Inc. Other critical files were acquired from the staff of the Survey and from other organizations that worked on the SSC project. Work was essentially completed on indexing these materials, and the final report, an index to the SSC Archives, was underway.

• **GIS for Geologic and Environmental Assessment,** *Erdmann, Krumm, Hindman, Joselyn (Illinois State Natural History)* One of the major strengths of the Illinois bid for the SSC was the use of the ENR Geographic Information System (GIS) for fine-tuning the placement of the ring and for environmental modeling. The GIS has been and is currently being used for a variety of other studies, including geology for planning, facility siting, and environmental impact studies. A publication in progress highlights these uses of the GIS with examples from statewide, county, and local levels. Written for a nontechnical audience, it emphasizes GIS use during the SSC bid process. In addition, a paper on the use of the GIS to generate plans for the disposal of excavated rock material was presented in Denver at a September GIS symposium sponsored by the National Academy of Sciences. The same paper was presented at the midwest regional ARC/INFO Users Conference in St. Paul in October.

• **Reclamation Along the SSC Seismic Lines,** *Berggren, Dodd* The high-resolution seismic work done to study the rock structure for the proposed SSC ring required drilling very closely spaced holes in four lines totaling nearly 17 miles in length. Because three of the four lines were drilled in ditches beside public roads, care had to be exercised to see that the holes were properly backfilled. A program was initiated to periodically inspect the lines and to backfill partially filled holes or those having settled fillings. This work was completed on June 30, but the Survey will maintain vigilance for any future settling that may require remedy.

• **Plugging and Monitoring of SSC Piezometers,** *Berggren, DuMontelle, Young, Dodd, Richter* Of the 33 piezometers established during the SSC investigation, 21 were plugged and the surface was restored. The remaining piezometers will continue to be monitored by the Illinois State Water Survey.

Environmental Impact Studies

Illinois Lands Unsuitable For Mining Program (LUMP), *McKay, Krumm* LUMP continues to provide support for the Geographic Information System (GIS). This program, funded by the U.S. Office of Surface Mining through the Illinois Department of Mines and Minerals involves all divisions of the Illinois Department of Energy and Natural Resources (ENR) and provides for compiling an automated database of areas permitted for surface coal mining operations in Illinois.

Mine Permit Review Project (LUMP), *Krumm, Graettinger, Pool, Taylor, Ploetz, L. Smith, Witzany* The Illinois GIS is being used to construct a detailed database of all coal mine permit areas in Illinois. Computer Research and Services Section (CRSS) staff have added to the Mine Permit Review (MPR) database by digitizing maps for 30 surface coal mines in Saline, Randolph, Jackson, St. Clair, Fulton, and McDonough Counties. CRSS staff also continue to manage this database and coordinate the project activities of all divisions of ENR.

PSTRAT Well Information Database (LUMP), *Graettinger, Taylor, Kraus, Pool, Helm, L. Smith, Krumm, Witzany* Well records continue to be added to the well database (PSTRAT) developed in conjunction with the MPR project. Mine permit applications contain well logs and other data that describe coal deposits and the nature of the overburden. This information, along with other data on file in the Survey's Geological Records Unit, is being entered into the PSTRAT database.

Environmental Property Assessments for the Illinois Department of Transportation (IDOT), *Bauer, Schneider, DuMontelle, Stohr with Erdmann, Miller, Summers, Bannon, Graese, Rimmer, Enloe, Dixon, Adams, McGovern, Trent* At the request of IDOT a contract was designed to develop procedures, evaluate methods, and organize an effective program to perform preliminary environmental site assessments on property that has been or will be acquired for IDOT and that may contain natural and manmade hazards. The initial proposal, which focused on basic organization and methodology, will be superseded by a FY90 proposal. Under this proposal, methods will be evaluated and more efficient procedures will be developed; in addition, up to 300 environmental site assessments will be performed during the contract year.

Preliminary site assessment includes the investigation of current and past land uses through a review of historical documents and data from computerized geographic information systems; on-site inspections; limited field analyses of soil, water, and air using various photoionization devices and gas chromatography; and report preparation using information from the above investigations in addition to available geologic, hydrogeologic, and other background data.

GEOLOGY FOR PLANNING

County Regional Studies

County GIS Screening for Landfill Siting, *McKay* In cooperation with the Illinois Department of Energy and Resources (ENR) Office of Solid Waste and Renewable Resources, Survey staff have met with Champaign, Crawford, Madison, Jo Daviess, Coles, Cook, and La Salle County officials to assist in the design of a GIS screening approach to landfill siting. These meetings have provided an opportunity to advise county officials of the availability of geologic maps for countywide landfill screening and to discuss with these officials criteria for screening analyses.

Champaign County—Geologic Assistance for Landfill Site Screening, *McKay, Killey, Kempton, Krumm, Trask, Gross, Smith, Pool, Denhart, Graettinger, Taylor, Ploetz, Junkins, Helm, Abert* The Survey is assisting the Champaign County Intergovernmental Solid Waste Disposal Association in developing geologic maps for screening the county for potential landfill sites. The effort includes the complete mapping of the surficial geology of the county using Survey well data to define materials to a depth of 75 feet. Data are displayed using a new mapping approach called a "slice map." Slice maps consist of eight maps of "slices" of the near surface. Each slice is bounded by a fixed depth, for example, 10 to 20 feet, 20 to 30 feet, or 30 to 40 feet. Slice maps are prepared from preliminary maps and cross sections that summarize the stratigraphic and lithologic information in the county; this helps identify areas capable of containing a landfill.

In addition, new mapping is underway to show all major drift aquifers, terranes, surface water bodies, streams, watershed boundaries, surface mines and pits, private and public water well locations, slopes, poorly drained soils, and wetlands.

Kane County, *Schneider, Curry, Seaber, Erdmann, Pool, Masters* The preliminary work for this project began as a direct result of information developed during the siting study completed for the SSC. As part of the SSC wrap-up tasks, both geologic and interpretative maps (including aggregate resource potential, land application of waste water, and aquifer distribution) will be produced from data developed in association with SSC investigations. A three-phase proposal to continue this work during FY90 was submitted to the Kane County Board so that a comprehensive and complete report can be prepared for inclusion in the Kane County revised master plan.

Perry County, Coal Mining, *Berggren* This project will provide basic geologic information useful to coal mine operators, public officials, and interested citizens involved in long-term planning for coal development in Perry County. Perry County is the leading coal-producing county in Illinois. Key logs have been compiled for each township in the county, and cross sections of the townships are being constructed to facilitate the identification of major stratigraphic units and the drafting of structural maps.

Geology for Planning in Logan County, *Vaiden, Kempton* A report entitled "Summary of the Geology and Hydrogeology of Logan County, Illinois: A Preliminary Review for Groundwater Protection and General Land-Use Planning" was submitted to the Logan County Planning Commission in December 1988, along with a preproposal entitled "Options and Recommendations for Further Study."

LAKE MICHIGAN COAST AND BASIN STUDIES

Activities for FY89 centered largely on the Illinois State Geological Survey/U.S. Geological Survey Cooperative Program for Southern Lake Michigan Coastal Erosion. The 5-year agreement under which the program operates provides for a minimum of 3 more years of federal support.

Bathymetric mapping of the Chicago nearshore began in FY89 and included the reach from Burnham Harbor south to 31st Street. A USGS specialist from Menlo Park provided program support. In the fall, parts of the Lincoln Park area were mapped, and sidescan sonar gear was used to broaden the study. The sonar gear provided excellent records of shore structures and bottom conditions for the entire Chicago shore.

Detailed mapping in northern Lake County supplied important data on sediment stabilities. Searches for antique maps, plats, photos, and diagrams provided information on shore development and erosion rates from early in the nineteenth century. Study of ancient lake levels continued with acquisition of new radiometric dates from Illinois Beach State Park and nearby areas.

Lake Michigan Database Development

Photographic Documentation of Lake Michigan Shoreline Changes, *Jennings, Terpstra, Dexter* A flight during September 1988 yielded more than 1,100 color transparencies that document changes along the Lake Michigan shoreline during the summer. On May 1 an extended photo flight was made of the Illinois shoreline with extensions into Wisconsin and down the Illinois Waterway. Approximately 3,000 aerial color slides were acquired. In addition to the aerials, 500 ground slides were added to the collections, which are used to reply to public queries and to supply basic data to scientific researchers.

Antique Map Acquisition for National Ocean Survey and National Archives, *Collinson, Jennings, Terpstra, Fucciolo* On May 10, 61 antique maps were examined at the National Ocean Survey (NOS) in Rockville, Maryland, and more than 100 at the new National Archives facility in Alexandria, Virginia. The NOS data are being transferred to the National Archives and will not be readily available. More than 20 additions were made to Survey map files.

Coastal Erosion Studies

Lake Michigan Shoreline History, *Jennings, Terpstra, Fucciolo* Information from maps and aerial photographs is being used to reconstruct changes of position of the Lake Michigan shoreline in Illinois from the nineteenth century to the present. Through the use of historical maps, shoreline positions and water depths have been digitized. ARC/INFO software is used to adjust older maps to match modern control. This software also computes areas and volumes to determine the quantity of sediment in motion along the shore. A series of detailed maps is in preparation for the area encompassing Loyola University in Chicago. Smaller-scale maps are being developed for various other areas, particularly in northern Lake County.

USGS-NOAA Great Lakes Basinwide Shore Erosion Initiative, *Lewis (University of Virginia), Jennings, Collinson* The University of Virginia, the U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA) are determining long-term average shore recession rates at 1,000-foot spacings throughout the five Great Lakes. For the study, Survey staff prepared 12 computer maps of Illinois (each 1:12,000 scale) showing the 1872 and 1988 shorelines of Lake Michigan.

Illinois Beach State Park Shoreline Erosion History, *Jennings and Collinson* Historic shorelines from 1873 to the present are being compiled. Nearshore profiles are being evaluated to provide standard profiles for calculating volumetric losses through time. General patterns show a continuing loss north of Dead River and a consistent gain south of Dead River to Waukegan Harbor. Comparisons of gain/loss volumes will provide important estimates of offshore losses. An early report will be presented to the 1989 Illinois Academy of Sciences.

Lake Michigan Framework Studies (Bathymetry and Lake-Bottom Morphology)

Monitoring Lake Bottom Morphology near North Point Marina, *Chrzastowski, Terpstra, Fucciolo, Riggs, Horstman* Coastal sedimentary changes near the newly constructed North Point Marina at the Illinois-Wisconsin state line are being monitored, as the coastal zone adjusts to the construction of the marina breakwaters and the dispersion and entrapment of nearshore sediments. Surveys in June 1988 and 1989 document lake bottom changes. Shoreline and beach changes continue to be monitored seasonally. These data assist marina engineers and managers in planning for additional shore defenses and for dredging of shoal areas.

Baseline data from the June 1988 and 1989 surveys were processed and used in generating a 1-foot contour map of lake bottom morphology. Slight shoreline changes and a southward revetment extension were identified through aerial photography. Draft copies have been distributed to the Illinois Department of Conservation, Kudrna & Associates, and Moffat & Nichol Engineers.

USGS Research Cruise--Research Vessel Neptune, *Chrzastowski, USGS crew* In Great Lakes Harbor aboard the R. V. Neptune (under lease to the USGS), Chrzastowski served as a research data recorder for the USGS crew. In support of Survey research, the Neptune crew measured bathymetry, conducted shallow geophysical soundings, took sidescan sonar images, and collected sediment samples along five transects to a depth of 10 km along the Lake Michigan shoreline in Illinois. The resulting data will be used to map lake bottom characteristics and to support studies of bottom erosion and sedimentary processes.

Sidescan-Sonar Survey of Chicago's Lakefront, *Chrzastowski, USGS staff* In October 1988, in cooperation with the USGS Branch of Atlantic Marine Geology, a dual frequency 100 to 599 kiloHertz (kHz) sidescan-sonar survey was completed along the entire Chicago lake front. This survey complemented the preliminary survey (summarized in Illinois State Geological Survey Environmental Notes 128) that was conducted along a limited reach of lake front in September 1987. In particular, the higher frequency imaging provided detailed sonar records along the seriously deteriorated shore structures of Chicago's Burnham Park. A proceedings paper and oral presentation summarizing the 1987 and 1988 surveys was presented to the international meeting of Coastal Zone 89, July 11-14, 1989, at Charleston, South Carolina.

Chicago Nearshore Bottom Morphology Survey, *Riggs, Shaw, Fucciolo, Chrzastowski* A nearshore bathymetric survey was conducted along the Chicago coast. A total of 60 profile lines were completed. An automated data collection system supplied by the USGS Branch of Marine Geology was used. The data were processed using a VAX computer and printed at a large scale. The map is being digitized and transferred to the Prime Computer (ARC/INFO) for editing.

Indiana Shoals Sidescan-Sonar Imaging, *USGS crew, Chrzastowski* As part of the ongoing cooperative research program with the USGS Branch of Atlantic Marine Geology, logistical assistance was provided during the December 1988 sidescan-sonar imaging of the Indiana Shoals. This is a prominent bathymetric high on the Lake Michigan extension of the Illinois-Indiana state line. Objectives of the survey were to evaluate sand resources and to gain data needed to interpret the geologic history of this area. The survey was highly successful. Through the generosity of the Great Lakes Dredge and Dock Co. a crew boat from New Orleans was provided in response to negotiations conducted by Mike Chrzastowski. Chrzastowski also participated as a crew member. The survey mapped a detailed sidescan-sonar mosaic of the shoal area identifying major commercial sediment deposits and mapping the lake subbottom.

Lake History Studies

Lake Michigan Lake Level and Sedimentation History (LLASH), *Hansel, Chrzastowski, Riggs, Miller, Follmer* As part of the joint U.S.Geological Survey/Illinois State Geological Survey Southern Lake Michigan Shore Erosion Cooperative Study to determine how the short historic (150-year) record fits into the long-term geologic record. Along with soil pits and hand-augered borings, 103 vibracores were collected. Stratigraphic information and radiocarbon dating are being used to determine the magnitude and timing of lake-level fluctuations that occurred during the past 4,000 years, postdating the large-scale fluctuations caused by glacial and postglacial uplift.

Process and Impact Studies

Nearshore Sediment Gain/Loss Trends for the Illinois Lake Michigan Shore, *Fucciolo, Terpstra* The Illinois Division of Water Resources provided $16,000 for a study to determine net gains and losses of littoral sediment on the Illinois Lake Michigan shore. Computer analyses of a series of bathymetric maps will be used to establish the rate at which littoral sediment is being lost beyond recovery offshore, and to determine the amount of internal movement within a sediment circulation cell. The project is in the Chicago Rogers Park District, where bathymetric maps are available for 1872, 1955, 1975, 1987, 1988, and 1989. Volume changes in lake bed sediment will be calculated by using ARC/TIN computer software.

Ice Effects and Transport of Sediment by Ice at Wilmette, *Miner, Collinson* Measurements were taken of nearshore profiles, ice thicknesses, sediment contained in ice, and beach changes caused by ice erosion. An 8-mm time-lapse camera was used to record ice formation, ice degradation, and changes of the shore. Up to 3 cubic meters sediment loss per linear meter of shore was documented for one winter season. A manuscript is being prepared for publication in the Illinois State Geological Survey Environmental Geology series.

Chicago Lakefront Earliest Historical Littoral Drift, *Chrzastowski, Terpstra* From 1833 through 1844, engineers of the U.S. War Department constructed and modified timber and quarry stone jetties to stabilize the mouth of the Chicago River. Historical maps showing beach accretion on the updrift side of these jetties were used to quantify the early- to mid-1800 littoral transport rates along Chicago's lakefront. These data provide a baseline for comparison of how subsequent urban lakeshore development has led to depletion of the littoral sediment supply.

Synthesis and Mitigation Studies

Mitigation Costs of Southern Lake Michigan Shore Erosion, *1986-1988, Collinson* In April 1989, a detailed summary of costs for mitigation of the Illinois shore was prepared at the request of the U.S. Geological Survey. The detailed report included municipal, county, state, federal, and private costs, including direct federal support to local communities and federal facilities. Costs totaling more than 17 million dollars were estimated for 1986-1988.

Scientific Review of Plans and Preparation for Loyola University of Chicago Lakefill Development, *Collinson* As chairman of the Loyola Technical Review Committee, Collinson prepared reports during early phases of the Loyola Lakefill Development Project covering revetment model studies, a review of schematic design, and support for application to fill 20.4 acres in Lake Michigan.

Environmental Geochemistry of Lake Michigan

Biological, Toxicological, and Bioaccumulation Investigation of Field Conditions at Indiana Harbor and Canal and Adjacent Lake Michigan, *Risatti, Ross (Illinois Natural History Survey)* A joint study with the Illinois Natural History Survey to assess the environmental significance of contaminants in Indiana Harbor and Canal (IHC) on the indigenous biota in the harbor and adjacent Lake Michigan included analysis at the Survey of 13 sediment samples and 42 biological composites (fish, crayfish, periphyton and plankton) from the study area. They were analyzed for total PCBs, total polycyclic aromatics (PAHs), major, minor, and trace elements, and, where applicable, total phenols, cyanide, ammonia, percent lipid, ash, and organic carbon. PCB concentrations in fish from the Indiana Harbor area ranged from 15 to 7,900 parts per billion (ppb), which is generally higher than in fish from Waukegan Harbor. PCB levels in sediments averaged 69 ppb with a range of 0 to 495 ppb; polycyclic aromatic compounds were below detection limits. IHC sediments contained approximately six times more cadmium, chromium, and zinc, three times more iron and nickel, and twice as much lead as any other nearby water system except the Cal-Sag Channel. Harbor sediments are heavily polluted with cadmium, chromium, copper, iron, manganese, nickel, lead, and zinc. Although concentrations of metals and organics decreased toward the mouth of the harbor, no determination was made whether contaminated sediments have been carried into the lake from the harbor. This project was funded by the U.S. Army Corps of Engineers, Chicago District. A final report has been accepted by the agency.

Chemical Analyses of Sediments and Biological Samples From the Waukegan Harbor Project Area, *Risatti* Eleven sediment samples and 30 biological composites (fish, crayfish and periphyton) from Waukegan Harbor were chemically analyzed. Sediments were analyzed for major, minor, and trace elements, total PCBs, organic carbon, phenols, and ammonia. Biological samples were analyzed for total PCBs, lipids, ash, and major, minor, and trace elements.

PCB levels in the biological composites were generally in the range of 2.7 to 1,987 ppb. From previous reports, we had expected values in the 10,000 to 20,000 ppb range. At this point, we don't know if PCB concentrations are decreasing in fish from Waukegan Harbor or if the fish that were analyzed had recently come into the harbor area. The average PCB concentration in the sediments was 196 ppb with a range of 15 to 627 ppb; our previous analyses of the sediments in the harbor found PCB concentrations ranging from 5 to approximately 17,000 ppb. The distribution was unexpected in that the highest average value (627 ppb) was found at a station located in the harbor channel leading to the open lake and not from sediments inside the harbor.

Average concentrations of eight metals of geochemical or environmental interest were compared to values found in sediments from Lake Calumet, Calumet Harbor, Little Calumet River, Lake Michigan, Cal-Sag Channel, and Wolf Lake. Waukegan Harbor sediments contain approximately one and a half times more cadmium and chromium, 13 times more sodium and, excluding the Cal-Sag Channel, one and a half times more zinc than other nearby water systems. Average concentrations of nine metals from the harbor and harbor area were also compared with sediments from other commercial areas in the Great Lakes and to a pollution classification index for Great Lakes harbor sediments. Harbor sediments are heavily polluted with cadmium, chromium, copper, manganese, and zinc. Compared to average metal levels found in fish collected from Lake Superior waters, fish from Waukegan Harbor and surrounding area were higher in lead (28x), zinc (3x), chromium (37x) and copper (3x). Waukegan Harbor fish, however, contained an order of magnitude less mercury and 40 percent less cadmium.

This project was funded by the U.S. Department of Defense, through the Chicago District of the U.S. Army Corps of Engineers. A final report has been delivered to the agency.

Field Evaluation of Membrane Bags as Biological Surrogates: Indiana Harbor and Canal Area, *Risatti* Experiments were conducted to determine if diffusion rates of organic contaminants into organisms could be estimated by using membrane bags as biological surrogates. A number of membrane bags filled with a trapping solvent, hexane, were suspended at two sites in the harbor. The bags were retrieved after periods ranging from 7 hrs to 30 days. The concentrations of total polychlorinated biphenyls (PCBs) and total polycyclic aromatic hydrocarbons (PAHs) in each of the bags were then evaluated by gas chromatography and gas chromatography/mass spectrometry to determine whether equilibrium had been attained with the PCBs and PAHs in the water column.

PCBs were found in concentrations ranging from 3.0 to 82.2 ppb and 9.8 to 286.8 ppb at the two stations. PAHs were not found in any of the bags. The data, although not indicating whether equilibrium had been attained, suggest that this procedure may be effective in monitoring levels of contaminants in aqueous systems and their effects on indigenous organisms such as fish. However, laboratory work is needed to normalize the procedure and to determine what effect various parameters have on bag diffusion rates. Funding for the field project has come from the Army Corps of Engineers, Chicago District, in conjunction with the Indiana Harbor and Canal project. A final report is being prepared.

Technology Transfer and Information Services

Lake Michigan Shoreline Inventory and Coastal Erosion Atlas, *Collinson, Jennings, Plummer, Morgan* Originally prepared in 1986, the computer file containing a listing of 563 riparian properties is being updated to 1989 status and will be made accessible to other agencies and property owners. A major part of this work, which will require at least 12 more months, involves revising the 1979 Coastal Atlas. A draft of the revised atlas has been completed for the entire Illinois shoreline. The draft identifies areas with major structural damage or erosion problems, areas with moderate to incipient damage, and shore protection structures built between 1986 and 1988. Copies of the draft, which includes significant information from county and municipal officials, have been distributed to the USGS, the Illinois Division of Water Resources, and contractors for the International Joint Commission.

Lake Michigan Bibliographies and Inventory, *Morgan, Holm* The Lake Michigan bibliography has been expanded by 342 new entries in recent months. To assist editing, an IBM PS2/30 computer and InMagic software were acquired. All of the entries (more than 7,000), their key words, and cross references have been entered into the machine. Morgan attended the June 1989 International Association for Great Lakes Research meeting in Madison, Wisconsin. Bibliographies and inventories were on display to publicize ISGS information on Lake Michigan.

RIVERS, BACKWATER LAKES, AND WETLANDS RESEARCH

Long-Term Ecological Research (LTER), *Cahill* The LTER methods manual was revised, providing a useful document for persons conducting ecological research on large rivers.

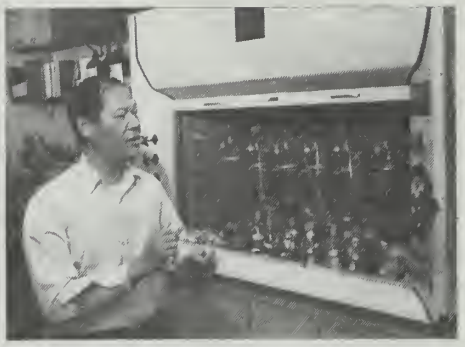
Scientists concerned with the declining population of fingernail clams collected cores in the Montrose Flats area of Pool 19 on the Mississippi River. The fingernail clam is the main food supply of migrating waterfowl. Samples of the cores were dated by counting cesium-137 radioactivity. The sedimentation rates determined by the Cs-137 method will be used to estimate times at which prominent shell layers were deposited, and this data then will be correlated with ongoing ecological studies.

Lower Cache River, *Cahill* In cooperation with the Illinois State Water Survey, sedimentation rates were determined at nine locations in the Lower Cache River Wetlands using cesium-137 dating. The rates ranged from 0.3 to 2.8 cm/yr since the early 1950s. The sedimentation patterns determined will help in conservation efforts to preserve these unique wetlands for Illinois.

A



B



C



D



E



(A) Geochemist James Risatti retrieves membrane bags suspended in Indiana Harbor. Risatti used the bags as biological surrogates to estimate the rates that contaminants diffuse into organisms. (B) Joseph Chou, an organic chemist in the Geochemistry Section, explains the laboratory process for extracting pesticide residues from water. The tests are part of statewide groundwater contamination studies. (C) Geologists Brian Trask and Myrna Killey, both of the Environment Studies & Assessment Section, prepare to record the results of a soil test conducted on the grounds of the Argonne National Laboratory. (D) Aerial photographs such as this one are used to document changes in the Lake Michigan shoreline. More than 4,000 color transparencies of the shore were taken during FY89. (E) Brenda Mehnert, engineer in the Earth Hazards/Engineering Geology Section, monitors damage in a cable installed by IMSRP researchers in subsiding overburden.

Investigation of Groundwater Conditions at the Des Plaines Wetlands Demonstration Project Site, *Hensel, Miller, Berg, Holden* An investigation of groundwater conditions continues at the Des Plaines Wetlands Demonstration Project. The purpose of the study is to evaluate the effects of construction and operation of the Des Plaines River Wetlands Demonstration project on the stability of the Des Plaines River channel and to document any changes in site groundwater hydrology. A severe drought in the summer of 1988 caused a large decline in water levels, which had not fully recovered by June 1989, even though spring rainfall had been plentiful. A groundwater model (MODFLOW) was calibrated for the northwest portion of the site, where the major construction has taken place. This modeling indicates that groundwater discharge into the river from the construction area is insignificant considering the capacity of the pumps at the site and the channel flow. The model predicts significant changes to groundwater flow rates and discharge to the river during wetlands operation. However, since flow rates and discharge are low to begin with, no adverse environmental problems are anticipated in the short term. Future research will focus on the groundwater/surface water interaction at this site.

Data from previous contracts with the U.S. Department of Fish and Wildlife (1986-1988) were compared with data gathered during this contract period. No significant or persistent changes that could be attributed to wetlands construction activity were detected during the contract period. Critical areas in terms of channel stability were identified and documented. The final report for the Illinois Department of Energy and Natural Resources contract WR-30 (July 1, 1988 to June 30, 1989) "Channel Response to Natural and Cultural Disturbance: Applications for Wetlands Management" was submitted in June.

HYDROGEOLOGIC INVESTIGATIONS

Groundwater Protection

A mission of the ISGS is to conduct pertinent mapping, assessments, monitoring, and technical assistance in support of protection and preservation of groundwater quality and management of groundwater resources. To facilitate these tasks the ISGS has been involved in several programs that provide needed information to regulatory agencies and state planning departments involved in groundwater protection. To date we have focused on assisting state agencies in targeting available resources in areas of critical need. A major effort was the development of an Appropriate Recharge Area Map, completed in February 1989, which will help establish and prioritize groundwater protection planning regions in the state. In addition, an ISGS-ISWS cooperative report recommending a design for a statewide survey of agricultural chemicals in rural private wells was released in May 1989.

Groundwater protection-related activities of the Illinois State Geological Survey during this past year's report period relate specifically to meeting the mandates of the Illinois Groundwater Protection Act. We have focused on the pilot pesticide study and the continuing evaluation of the impact of pesticides on groundwater, and on the mapping of appropriate recharge areas. In discussions with the Illinois Environmental Protection Agency (IEPA), we have jointly added to the list of priorities the development of a methodology for conducting groundwater protection (community) needs assessments, and the initiation of a viable program of data management and automation. We are in the formative stages of these programs.

Appropriate Recharge Areas of Illinois Map, *Keefer, Berg, Dey* In compliance with the Illinois Groundwater Protection Act, the Survey submitted to the Illinois Environmental Protections Agency (IEPA) and the Interagency Coordinating Committee on Groundwater a map showing recharge areas in the state. Recharge areas are ranked according to the relative potential of geologic materials to transmit water, importance of aquifers as groundwater supplies, and soil infiltration rates. This map will be combined with information supplied by the Illinois State Water Survey on the statewide distribution of potential sources of contamination. The IEPA and the Surveys will use these data to identify areas with extremely high potentials for groundwater contamination, to set up groundwater protection planning regions, and to target regions for which detailed studies are most urgent.

Evaluation of the Potential Impact of Current Surface Waste Activities on Shallow Groundwater Contamination, *Keefer, Perry (HWRIC), Greenpool, Berg* A series of statewide maps were compiled for the Hazardous Waste Research and Information Center (HWRIC). These maps show the density of current waste generation and disposal practices. They were overlaid, using the Geographic Information System, with a map showing the potential for contamination of aquifers in Illinois. These composite maps identify areas where the density of current waste activities may be a significant threat to groundwater resources.

Hydrogeologic Applications to Regional Three-Dimensional Lithostratigraphic Mapping, *Kempton, Berg, Soller (U.S. Geological Survey)* A paper and poster were prepared for the International Symposium on Hydrogeologic Maps as Tools for Economic and Social Development, which was held in Hannover, Federal Republic of Germany, May 31 to June 2, 1989. The paper and poster stressed the development of a good geologic framework for incorporation into hydrogeologic maps. Also emphasized were the problems that commonly confront the use of hydrogeologic information, and the need to conduct regional geologic investigations prior to conducting site-specific studies for waste disposal.

Numerical Estimates of Potential for Groundwater Contamination from Land Burial of Municipal Wastes in Illinois, *Hensel, Berg, Griffin* The objective of this research was to quantitatively rank the potential for groundwater contamination from burial of municipal waste for several mapped hydrogeologic scenarios common to Illinois. This research also included an evaluation of the appropriateness of a regulatory compliance distance of 100 feet for maximum leachate migration from municipal landfills. The distance has been proposed by the Illinois Pollution Control Board (IPCB). Results show that the numerical ranking of contamination potential is possible and that the proposed 100-foot compliance distance may be appropriate. The project was sponsored by the Hazardous Waste Research and Information Center and the IPCB.

Impact Assessment of Proposed Landfill Regulations, *Keefer, Berg* A series of maps has been generated using the Geographic Information System. The maps illustrate the availability of land for nonhazardous waste landfills and, based on proposed landfill regulations, the potential for contamination of shallow aquifers in those areas. This project was funded by the IPCB, and the maps showed the availability of land for various uses of possible concern to the IPCB. Information on land coverage and aquifer vulnerability was tabulated on statewide and county levels.

Agricultural Chemicals in Rural, Private Water Wells in Illinois: Recommendations for a Statewide Survey, *McKenna, Dreher, E. Mehnert, Mravik, Coleman, J. Chou, Valkenburg, Dey, Mushrush, Panno, Keefer, Greenpool (Illinois State Geological Survey); Schock, Caughey (Illinois State Water Survey)* The results of this study by the Illinois State Geological and Water Surveys have been published as Illinois State Geological and Water Surveys Cooperative Groundwater Report 11. The report presents recommendations for the design of a statewide survey to assess the level of occurrence of agricultural chemicals (pesticides and nitrates) in rural private wells. The project is a response to the mandate of the Illinois Groundwater Protection Act to evaluate the impact of pesticides on groundwater, particularly in rural areas where pesticides are most intensively used.

A pilot study conducted by the Surveys in cooperation with the Illinois Department of Agriculture will (1) implement recently developed U.S. EPA analytical methods for pesticides; (2) test protocols for well-site characterization, sample collection, and data management; and (3) evaluate criteria used in estimating the potential for agricultural chemical contamination of rural, private wells. Chemists at both Surveys are currently evaluating the U.S. EPA methods. Five township-size areas representative of hydrogeologic conditions and agricultural practices in Illinois have been selected for sampling in Mason, Kankakee, Livingston, Piatt, and Effingham Counties.

Persistence and Mobility of Selected Pesticides in Loessial Soils of Illinois, *McKenna, Bicki, Dey, Roy, Miller, Coleman, S. F. Chou, Valkenburg* The movement and persistence of alachlor and atrazine were monitored over a 14-month period in four loessial soils having a range of organic carbon content and different natural soil drainage characteristics. The greatest mass of pesticide residues was retained in the upper 20 cm of all soils throughout the study period. Trace levels of the applied pesticides were detected below 20 cm following application in the spring. Greater leaching, attributed to preferential flow, occurred in the Alfisols as compared to the Mollisols. Differences in the depth of leaching of alachlor and atrazine observed 12 months after application were apparently the result of differences in their relative persistence. The level of pesticides remaining in surface horizons 1 year after application also varied within each soil. The final report will be published by the Illinois Department of Energy and Natural Resources.

Evaluation of Discharge from Drainage Tiles for Characterizing Pesticide Migration into Groundwater, *Keefer, Bicki (University of Illinois Agronomy Department), McKenna* Pesticide residue levels in drainage tile effluent, soil water, and shallow groundwater are being monitored as part of a multiyear project funded by the Water Resources Center. The focus of this past year has been primarily on continuing tile effluent and soil water sampling following major precipitation.

Assessment of Potential for Contamination by Agricultural Chemicals in Boone County, Illinois, *Dey, McKenna, Bicki (University of Illinois Agronomy Department), Berg* Information is being prepared to evaluate the potential for groundwater contamination by specific pesticides at the farm level. Computer modeling to predict the fate of pesticides in soils was completed, and computer graphics were generated to communicate modeling results. Some technical sections of the final report have been written; however, the project was suspended in January 1989. Work will resume after the completion of priority work on Illinois Groundwater Protection Act projects.

Alteration of the Herbicide Dicamba (Banvel) by Anaerobic Bacterium, *Risatti* Dicamba is the common name for 3,6-dichloro-2-methoxy-benzoic acid, which is marketed as a herbicide under the trade name Banvel. Although Dicamba has been shown to be biodegradable in aerobic soils, its persistence in anaerobic sediments is not well known. Initial experiments indicated that pure cultures of an acetogenic bacterium can be induced, under strict anaerobic conditions, to de-methoxylate Dicamba. The product is thought to be 3,6,-dichloro-2-hydroxy-benzoic acid, which is more soluble in aqueous systems than the parent compound. Although this product has an LD_{50} approximately 200 times greater than Dicamba, it may be more readily degraded to CO_2 and Cl^- by pathways analogous to chloro-phenol and chloro-benzoic acid degradation. It is postulated that the organism obtains energy and cell carbon from the methoxyl carbon with the possible production of methanol as an intermediate.

Hydrogeology Research Laboratory

The Hydrogeology Research Laboratory was formed December 1, 1988, as a basic research unit focused on groundwater and chemical movement in low permeability sediments such as glacial till and shales. These studies support the Survey's efforts in both groundwater resources and groundwater protection. The laboratory will also address other significant research issues as they arise. Planning is in progress to revitalize the hydrogeology laboratory, now in room 435 of the Natural Resources Building, so that new projects can begin in the fall of 1989.

Hydrogeologic Processes

Field Study of Transit Time Through Compacted Clays, *Cartwright, Krapac, Herzog, Panno, Hensel, Rehfeldt* This study is funded by both the U.S. Environmental Protection Agency and the Hazardous Waste Research and Information Center. The study began in 1985, and it should continue until at least 1991. A new high pressure liquid chromatograph was purchased for improved analysis of the chemical tracers for FY90. Proposals have been submitted to the U.S. EPA for FY90 funding; prospects are very good for continued support.

The experiment consists of a 8x15x0.9 meter clay liner ponded with 30 cm of water. The liner performance is monitored using a total of 218 instruments in and on the liner. Data show that the hydraulic conductivity (approximately $4x10^{-8}$ cm/sec) is significantly lower than the EPA maximum ($1x10^{-7}$ cm/sec). The wetting front has penetrated to between 40 and 50 cm since ponding in April 1988; breakthrough of the tracers is now estimated to be between 2 and 4 years.

Use of Environmental Isotopes to Evaluate the Hydrogeology of Selected Tills in Illinois, *Panno, Cartwright, Coleman, Liu* Preliminary investigations are underway to determine the usefulness of environmental isotopes in evaluating recharge and discharge to and from a prairie aquifer. A review of the literature is presently underway.

WASTE MANAGEMENT

The waste management research program at the Survey has two major thrusts: site screening and characterization studies for proposed waste disposal facilities, and more generic studies that relate to the movement of chemicals in the subsurface and our ability to monitor this movement. Our largest site characterization study this year is related to the state's need to select a site for the disposal of low-level radioactive wastes. Projects concerning chemical movement in the subsurface are studying deep well injection of hazardous wastes and the mobility of incinerator-ash leachate.

Survey scientists provide extensive information to other state agencies and the public on waste disposal issues. Responses to requests for information on specific waste disposal sites and on general waste disposal issues increased significantly in the past year. In addition, the Survey has a service contract with the Illinois Environmental Protection Agency (IEPA) specifically to provide information and technology transfer on Class I injection wells.

Landfill Siting

Statewide Landfill Inventory Update, *Mehnert, Mushrush, Hazardous Waste Resource Information Center* The Inventory of Land-Based Disposal Sites was updated with data provided by IEPA and the Northeastern Illinois Planning Commission. Thirty-four requests were filled for information regarding the database and the contents of the database. The final report for this project is in review.

Technical Support to McHenry County in the Siting of a Regional Pollution Control Facility, *Herzog, Hansel* This county-supported contract provides technical assistance in the siting of a new regional sanitary landfill. McHenry County is committed to locating a new facility in the most capable geological materials. Survey staff met with McHenry County staff to select potential geologic locations from a series of sites that already meet nongeologic criteria. Following this meeting, the county selected a site to begin geologic exploration. The Survey will provide technical advice to county consultants regarding field work on the selected site and review all engineering reports of the field studies.

Hazardous Wastes

Groundwater Monitoring and Modeling with Biodegradation of Organic Pollutants at Wilsonville Waste Disposal Site, *J. Chou, Herzog, Valkenburg* Evaluation of historical data from the site of cleaned-up hazardous wastes indicates changes in the concentrations of volatile chemicals in samples collected over the past 2 years. The affects of waste excavation are obvious for the more mobile compounds, but were not detectable in groundwater samples for the less mobile compounds. The U.S. Geological Survey MOC Model was used for the groundwater flow modeling study. The calibrated data indicated agreement between simulated and measured values. Calibrated data can be used to determine velocities needed for future biodegradation modeling. Biological activity of the indigenous microorganisms in soil microcosms was very low; these microorganisms degrade aromatic hydrocarbons. The detectable rate of biodegradation of aromatic hydrocarbons in this study corresponds to halflives of 35.7 to 192.5 weeks.

Optimal Time for Sampling of Organics in Fine-Grained Materials, *Herzog, J. Chou, Valkenburg, Griffin* Most guidelines for sampling groundwater require the evacuation of multiple bore volumes from the well before a sample is collected. Such recommendations are for wells finished in fine-grained deposits with very low recharge rates are not practical to implement. Therefore, this study was designed to determine the changes in volatile organic chemical concentrations that occur while slowly recovering wells refill after evacuation. Three hundred samples were analyzed for up to 19 different volatile organic compounds from 11 wells finished in shallow, fine-grained glacial deposits. Results showed no significant differences in volatile organic chemical concentrations at any time up to 48 hours, the latest sampling time used, after well evacuation. However, concentrations were significantly lower before than after evacuation.

Results of this study were published as "Changes in Volatile Organic Chemical Concentrations After Purging Slowly Recovering Wells" in the fall 1988 issue of Ground Water Monitoring Review. This paper won the journal's best paper award for 1988.

Characterization of Products from Incineration of Infectious Waste, *Kruse, Dreher, Dickerson, Steele, Rostam-Abadi, Chen, Smith (National Environmental Services); Rood, Suidan (University of Illinois)* The Survey, in cooperation with National Environmental Services, Inc. (NES) and two staff members in the Civil Engineering Department of the University of Illinois, developed and submitted a proposal to the Hazardous Waste Research and Information Center (HWRIC) to develop baseline data on the burning of infectious hospital waste at NES's Clinton facility. NES is considering the co-firing of coal and hazardous waste to raise steam for its industrial parks. The projected use of coal and interest in the problems that may arise for disposal of incinerator wastes prompted ISGS involvement. The project was not funded this year but HWRIC has requested that the project be resubmitted during the next request for proposals.

Clay and Hazardous Wastes, *Hughes, Moore* Because clay minerals act as barriers and absorbents for most types of hazardous wastes, research continues to locate clay-rich strata for waste disposal. This work supports development of methods to clean up or seal existing waste sites and techniques to use special clays for the safe storage of wastes in new sites. Consultations with industrial producers of absorbent clays have focused on improving a proposal for research on using hydrophobic clays for the safe storage and disposal of hazardous hydrophobic waste liquids. All major absorbent clay companies are based in Illinois and thus could provide essential technical support for submissions to state and federal agencies. A chapter on the interactions of clays and certain types of organic hazardous wastes has been completed for the final report of investigations at Wilsonville.

Mobility of Incinerator-Ash Leachate in Compacted-Soil Liners, *Roy, Krapac* Supported by the U.S. Environmental Protection Agency (U.S. EPA), the Survey began a project to assess the efficacy of soil liners in protecting groundwater from contamination by municipal solid waste (MSW) ash leachate. Incineration is gaining a prominent role in solid-waste management because of the increasing scarcity of landfill space; but there are environmental concerns about the disposal of ash residues. A position paper will be written to summarize the state of knowledge of ash leachate-soil interactions; it will include recommendations for future research. This document will be used by the U.S. EPA to help promulgate regulations on ash disposal. Laboratory studies will begin this winter, based on the position paper.

The conclusions reached at this time are that (1) little data are available on state-of-the-art incinerators and current disposal practices; (2) ash tends to contain relatively high concentrations of selected metals and halides, most notably cadmium, lead, and chloride (however, MSW ash yields an alkaline reaction when it comes in contact with water, minimizing the release of heavy metals); (3) migration of many potential pollutants in ash leachate will likely be attenuated in soil liners by adsorption/precipitation reactions, but metal-ligand complexation and competitive adsorption interactions may result in the enhanced mobilization of some potential pollutants

(quantitative data on this topic is very limited); (4) no data are available on how ash leachate will affect the hydraulic conductivity of a soil liner (related studies suggest that the leachate will not adversely change the permeability of a liner, but this hypothesis needs to be tested); and (5) heavy metal-groundwater contamination from ash disposal has occurred, but specific sites where this occurred were poorly designed and operated. It appears likely that long-term groundwater contamination at future sites will include enhanced levels of chloride, sodium, and sulfate, but it is uncertain whether heavy metals will pose a threat to groundwater supplies.

Geochemical Fate of Deep-Well Injected Hazardous Wastes, *Roy, Seyler, Steele, Krapac* This laboratory study began in January and was funded by the Hazardous Waste Research and Information Center. It is a continuation of a previous project funded by the U.S. Environmental Protection Agency and reported in the 1987-1988 Annual Report of the Illinois State Geological Survey. The overall objective of this study is to investigate whether the geochemical fate of injected liquid wastes can be predicted by the use of thermodynamic models. Geochemical modeling is currently being used by industry to obtain permits to inject wastes, but little experience or data exists in this area. In this study, liquid samples of two hazardous wastes are being equilibrated for 230 days with rock samples that were collected from host formations chosen for injections in Illinois. These experiments will be completed in the fall, at which time we will compare the chemical and mineralogical composition of the rock-waste systems with that predicted by modeling.

Low-Level Radioactive Wastes

Geologic and Hydrologic Factors for Siting and Characterizing Hazardous and Low-Level Radioactive Waste (LLRW) Disposal Facilities, *Berg; Wehrmann, Shafer (Illinois State Water Survey)* Since 1985 the Illinois State Geological and Water Surveys have assisted the Illinois Department of Nuclear Safety (IDNS) in siting and characterizing a site for LLRW disposal. Two final reports were presented to IDNS in January 1989. The first report reviewed site-specific criteria and recommended the consideration of geologic and hydrologic factors. The second report presented a recommended methodology for siting and site characterization. These two reports were combined, and additional information was added to include siting and site characterization efforts for locating hazardous waste disposal facilities. The suggested procedures for conducting LLRW investigations incorporate three steps: (1) regional screening, (2) area screening, and (3) site characterization.

Characterization Studies for Low-Level Radioactive Waste (LLRW) Disposal Facility Siting, *Berg, Curry, Tierney, Cartwright* The Survey provides support to the IDNS and its primary subcontractor, Battelle Memorial Institute, for site-characterization efforts in anticipation of the siting of a LLRW dispoal facility in Clark or Wayne County. Our principal role is to review environmental impact reports and documents on site characterization activities. We also prepared a detailed report on the glacial geology of the Clark County region to supplement the site-specific geologic characterization activities.

Pending additional data collection associated with the recently approved Supplemental Data Collection Program, the Survey will be updating its geologic report; we anticipate submitting a more comprehensive document to Battelle in November. The Survey is working closely with Battelle in establishing the necessary elements that are essential to adequately characterize the candidate sites during this Supplemental Program. In addition to a revised and updated geologic report, the Survey was involved in additional document reviews, participated in field activities, met weekly with technical advisory meetings in Martinsville, and participated in QA/QC activities.

Coal Wastes

Factors Affecting Management of Fine-Coal Cleaning Waste Solids, *Dreher, W.-T. Chen, Rapp, Rostam-Abadi, Roy, Steele, R. Frost, J. Frost, Henderson, R. L. Berger (University of Illinois), others (Southern Illinois University)* The environmentally acceptable disposal of or

beneficial use of three fine-coal cleaning waste solids was studied. During the reporting period, a column leaching test, which incorporated wetting and drying steps, was performed to simulate disposal in the unsaturated zone or on the surface.

Samples of one waste solid were mixed in various proportions with portland cement to test the strength development of the stabilized waste. Compressive strengths in excess of 300 pounds per square inch were developed in some of the mixtures. When waste solid was mixed with portland cement, it was found that a component of the waste leachate, possibly ferric sulfate, interfered with the cement hydration reaction. Adequate compressive strengths could still be developed, but this required greater proportions of cement and longer curing times than are normally expected. In a large-scale disposal operation, the extra cost of the cement could cause the process to be economically undesirable.

Two possible methods for the beneficial use of the waste solids found to be feasible were combustion of the waste in a fluidized bed to recover the thermal value of the waste, and microbially assisted leaching of valuable metals from the waste. Combustion of the waste was conducted in a test at SIU-Carbondale. A waste solid that produced alkaline leachate resulted.

Technology Transfer and Information Services

Underground Injection Control Class I Service Program, *E. Mehnert; Illinois State Water Survey staff* The Geological and Water Surveys continue to provide technical expertise and advice to the Illinois and the U.S. Environmental Protection Agencies, Region V, in Class I Underground Injection Control. This advice pertains to the permitting and testing of injection wells and the Land Ban Petition process. Operators of the three wells that inject hazardous waste must petition U.S. EPA to be permitted to continue injecting waste. Staff of both State Surveys are part of a multi-agency group that has completed a preliminary review of these voluminous documents. Development continues on a computerized database that could be used during the review process and increase its efficiency.

Service Requests for Landfill and Groundwater Monitoring Information, *Herzog* Requests for information were received from consultants, citizens, industries, and governmental agencies desiring to evaluate potential and existing sites for landfills; information also was sought on groundwater monitoring. Responses included 111 phone calls, 15 preliminary hydrogeologic investigations, 76 letter reports, and 27 office visits.

EARTH HAZARDS AND GEOTECHNICAL STUDIES

Radon, *Cahill* The Survey has provided guidance to the public, the media, and other state and federal agencies on geologic aspects of the indoor radon issue. In support of a unfunded state radon program the following activities were performed:

- **Radon Measurements** The Survey participated in Round 5 of the U.S. EPA Radon Measurement Proficiency Program. A Quality Assurance Manual and a Standard Operating Procedure Manual for indoor radon measurements were approved for participation in Round 6 of the USEPA Radon Measurement Proficiency Program. In cooperation with the University of Illinois Office of Environmental Health and Safety, 12 university buildings were tested for radon. No high levels were found in rooms that were being occupied for offices or teaching.

The concentrations of radon in natural gas from 12 different producing gas fields in Illinois ranged from 30 to 134 pCi/L. These levels represent no health risk to the consumers when the gas is used in conventional applications.

• **Indoor Radon Data File** Data on indoor radon were acquired from private companies and the Illinois Department of Nuclear Safety. Data from approximately 16,000 measurements are now included in the data set. Locations and dates of measurements are also included in the set. The data are being plotted by zip codes using the Geographic Information System with the support of the Computer Research and Services Section.

• **Legislative Review** Written testimony was provided to the U.S. House Subcommittee on Oversight and Investigation, Committee on Interior and Insular Affairs, on the applications of geology to mapping of the potential for radon gas emanation. Written reviews of three bills dealing with radon that were pending in the Illinois legislature also were provided.

Karst Topography

Glaciation and Saline-Freshwater Mixing as a Possible Cause of Cave Formation, *Panno, Bourcier (Lawrence Livermore Laboratory)* The work presents a conceptual model of a possible mechanism for karst and cave formation in the eastern midcontinent region of the United States. The model denotes Pleistocene glaciation as a mechanism for forcing basin-derived saline water into near-surface aquifers. The resultant saline-freshwater mixing in limestone would cause the dissolution of significant amounts of limestone and initiate the formation of karst features such as caves. This work includes the results of computer-simulations of brine-freshwater mixing using the water-rock interaction program EQ3/6.

Landslides

Landslide Study at Chester, Illinois, *Su, Stohr* Excess water is a major cause of unstable slopes in Chester. Water samples were collected for testing to determine the possible source of water at a slope near the Chester high school stadium. The probable source was either a shallow groundwater aquifer or a broken city water line. As noted in last year's preliminary report, results of chemical tests showed high chloride and fluoride concentrations, indicating that the source was probably a broken water line.

Earthquakes

Seismicity of Illinois, *Heigold, Larson* In response to the many requests for evaluation of seismic risk in Illinois by planners, builders, insurance companies, and citizens, a study of the seismicity of Illinois has been made. This study examines the historical record of seismicity in detail and documents that the New Madrid Seismic Zones in Missouri is the greatest source of seismic risk for southern Illinois.

Illinois Mine Subsidence Research Program

The Illinois Mine Subsidence Research Program (IMSRP) was established in 1985 to develop guidelines for underground mining methods that would maximize coal extraction while preserving the productivity of prime farmland in Illinois. The program is also addressing the needs of the mining industry for subsidence predictions and for calculation of stable mine conditions for room-and-pillar mines. The program was initiated at the request of the Illinois Coal Association and the Illinois Farm Bureau and is directed by the ISGS. Work is being coordinated between the U.S. Bureau of Mines, University of Illinois at Urbana-Champaign (departments of agronomy and civil engineering), Southern Illinois University at Carbondale, Illinois Department of Mines and Minerals, and Northern Illinois University. Funding is provided by the Illinois Coal Development Board and the U.S. Bureau of Mines.

Illinois Mine Subsidence Research Program (IMSRP), *DuMontelle, Bauer, Trent, Brutcher, B. Mehnert, Van Roosendaal, Hasek* Activities from July 1987 through June 1988 were documented in a Program Assessment Report approved by the Illinois Coal Development Board (ICDB) In December. Proposals for 1989-90 were reviewed by outside experts and the technical committee during fall of 1989. A Program Implementation Plan for 1989-90 was approved by the ICDB at its March meeting. Projects included in the plan were finalized, and contracts were implemented through the University of Illinois.

Surface subsidence and overburden deformation were monitored during mining of two adjacent longwall panels in Jefferson County. Instrumentation is being installed at another longwall site in Saline County, which will be undermined in early 1990. At these locations, Colin Booth, hydrologist from Northern Illinois University, is investigating the piezometric response to subsidence in the drift and bedrock. Robert Darmody of the Agronomy Department, University of Illinois, is continuing work on the effects of subsidence on agricultural soils and the impact of current subsidence mitigation practices on crop yields.

Paul Chugh of Southern Illinois University directed an ongoing project on surface subsidence monitoring. In cooperation with the Survey, Chugh is working with Damberger of the Survey's Coal Section in a new project to identify characteristics of Illinois mines in regard to their geology and mine stability problems. James Mahar of the University of Illinois Civil Engineering Department continued to work with Hasek to test Illinois coal and assess the effect of sample size and shape on its strength.

Time Domain Reflectometry, *Bauer, Brutcher, B. Mehnert, Van Roosendaal* Investigators continue to search for a simple way to monitor subsidence movements in bedrock. Recordings of electronic test signals from two coaxial cables that were grouted into boreholes over a longwall panel in Jefferson County have documented the progressive movement of bedrock overburden strata to the ground surface. Another cable was recently installed at a Saline County longwall site. Also, a cable was installed in an active subsidence event associated with an abandoned mine in southwestern Illinois. This event is damaging a grade school in Collinsville, Illinois. As with the earlier studies, Charles Dowding of Northwestern University assists with these investigations. A draft of the final report on this project was submitted to the funding agency, the U.S. Office of Surface Mining.

Rock Mechanics and Geotechnical Support Studies

PC-Based Data Acquisition System for Rock Mechanics, *Su, Hasek* A data acquisition system set up for personal computers (PCs) is being used to measure and store data on the strength and deformations of rock samples as they are being tested for strength is being used for coal and rock samples from various projects in the Illinois Mine Subsidence Research Program (IMSRP). The system was improved during this period through the building of a new signal conditioner, which greatly reduces electronic noises and hence increases the measuring resolution of the system. New software was acquired that concurrently converts the electronic signals to appropriate physical values (stress, strain, Poisson's ratio, and deformation modules). These physical values are simultaneously displayed on a monitor in both data table and X-Y plots. At the end of a test, the results are saved on disk in LOTUS 1-2-3 file format.

Technology Transfer and Information Services

Mine Subsidence Information Dissemination, *Trent, Bauer, DuMontelle* An IMSRP industry briefing was held in Mt. Vernon. IMSRP contractors reported on their projects to attendees, who included Farm Bureau representatives, Illinois Basin coal operators, members of the IMSRP Advisory Board, engineering consultants, and representatives of state and federal agencies. Twelve scientific papers were presented, and copies were provided for each participant. All IMSRP publications also were available.

Bibliographic searches on the IMSRP database were filled in response to requests from the coal industry, subsidence researchers at other universities, and the Abandoned Mined Lands Reclamation Council. A handout of references on groundwater and mine subsidence was prepared for the Indiana Water Resources Association Symposium in June, in conjunction with IMSRP presentations. The IMSRP display was exhibited at several different functions around the state. A press release was mailed during June to announce the availability of IMSRP publications.

Evaluation of the Exposure of the Population and Urban Development to Potential Subsidence from Underground Mines, Through Comparison of Mined-Out Areas, Urban Lands, and Population Density, *C. Treworgy, Hindman, Pan, Baxter* This project is now in its last phase. For each county in the state that has had some underground mining—coal or other minerals—tables and maps are being prepared that show the land acreage and number of housing units that may be exposed to subsidence. This data was contracted for by the Illinois Mine Subsidence Insurance Fund (IMSIF). Following review of the final report by IMSIF, the data will be made available to the public through the Survey's Environmental Geology Notes series.

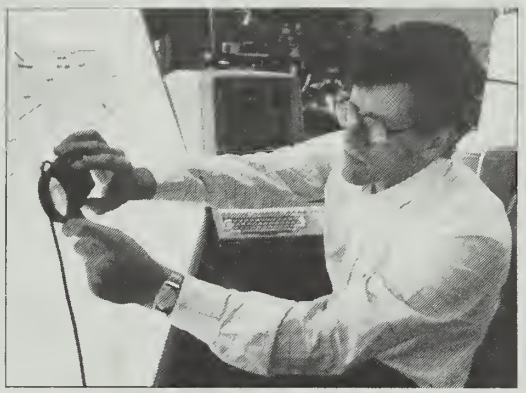
Computer-Assisted Directory of Mine Subsidence Insurance Claims, *Hindman, Schwartz, Weiss, Coates, DuMontelle, Bauer* The Illinois Mine Subsidence Insurance Fund (IMSIF) renewed support for the PC-INFO database until June 1990. Funding for the directory has continued since 1983, and there are now more than 3,700 records of claims in the database. Included are data on structures damaged, causes of damage, location of insured structures, and information on underlying mines.

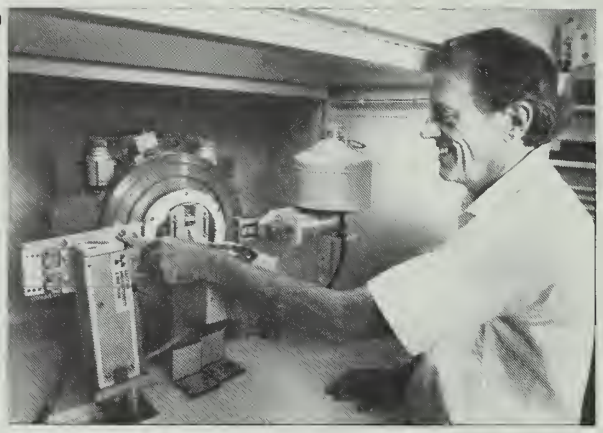
A workshop for mine subsidence insurance consulting adjusters was hosted by the IMSIF in Chicago. The newly designed two-page ISGS data forms to be completed by the adjusters were introduced and explained. Also discussed was the possibility of ISGS making Geographic Information System (GIS) maps at 1:24,000 of mined-out areas for the adjusters to use in their investigations, and the digitizing of mine maps for this purpose.

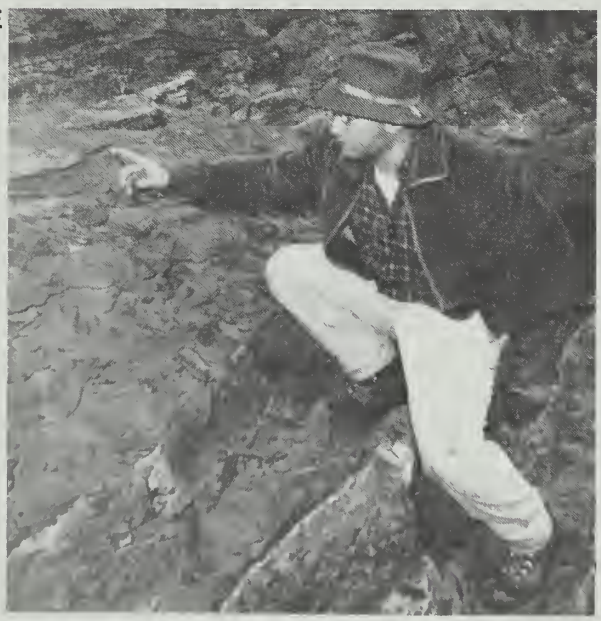
General and Basic Research











(A) Eltricia McMillion, Isotope Geochemistry Laboratory, operates a vacuum system that prepares geochemical samples (such as soil bone collagen, and oil) for isotopic analysis. (B) John Nelson, Coal Section, and Stephen Marshak, U of I, examine a rock outcrop while mapping the geology of southern Illinois. (C) Donald McKay, Computer Research and Services Section, uses the Survey's Geographic Information System (GIS) to digitize a surface coal mine map. (D) Duane Moore, Clay Minerals Unit, uses an X-ray defraction instrument to analyze mineral composition. (E) Joseph Devera, Coal Section, points out a geologic structure in sandstone in southern Illinois.

GENERAL AND BASIC RESEARCH

General and Basic Research at the Illinois State Geological Survey includes programs and projects with such wide applications that they cannot be specifically categorized as either Mineral Resources or Environmental Geology. Fundamental results from research on stratigraphy, structural geology, paleontology, clay mineralogy, and other basic disciplines often provide the framework for applied studies of mineral resources and the environment. For example, biostratigraphic investigations have provided an important tool for correlating coal beds and hydrocarbon-bearing strata, and thus have aided in the development of the coal and petroleum industries. Studies in glacial geology have provided essential information about shallow aquifers as well as an understanding of the timing, magnitude, and causes of lake-level fluctuations. Study of the Earth's crust beneath Illinois and adjacent states is leading to knowledge of the deep structures along which earthquakes occur, and to the definition of deep oil and gas plays and mineralized zones. We are gaining a better understanding of how to predict the nature and distribution of sedimentary rocks and to correlate geologic events. Comparative data from other basins in the world provide important insights about the evolution of the Illinois Basin.

CRUSTAL STUDIES

Through crustal studies, we are investigating the character of the earth in and around the Illinois Basin. Knowledge of the nature of the crust is essential to understanding the origin and development of the Illinois Basin and the distribution of the natural resources in the basin.

The crustal framework of the Midcontinent has become much clearer in recent years as a result of regional geophysical studies. Examples of such studies include deep seismic reflection profiling across the Illinois Basin by the oil and gas industry and by the Consortium for Continental Reflection Profiling (COCORP), deep seismic refraction profiling in the Reelfoot Rift portion of the New Madrid Rift Complex by the U.S. Geological Survey (USGS), and regional potential field (gravity and magnetics) studies by several federal and state agencies (including the Illinois State Geological Survey) and universities. Analyses of the data from these studies are far from complete, and in some cases, acquisition of more data is planned. COCORP plans to conduct additional deep seismic reflection profiling in the Illinois Basin. Certainly more deep refraction profiling in and around the New Madrid Rift Complex is desirable. The National Seismic Network, a joint venture between the Nuclear Regulatory Commission and the USGS, includes plans to install several permanent seismograph stations in and around the Illinois Basin in the near future. The Survey is working with the USGS to select the best location(s) for new seismometers in Illinois. Information provided by these stations will enhance the knowledge of the crust already provided by the existing seismograph network in the Midcontinent.

Reflection profiling by industry has focused primarily on the Phanerozoic rocks of the earth's crust. Such profiling is currently being conducted by such companies as Seismic Specialists, Inc. and Compagnie Geophysique Generale. Acquisition of these and other proprietary data are being pursued by the Illinois State Geological Survey to increase its seismic library, a vital database for basin analysis.

All of these data, particularly the shallower reflection data, are being used with existing borehole information to construct geological and geophysical cross sections of the Illinois Basin. These cross sections ultimately will be incorporated in Global Geoscience Transects, a project in the initial stages of implementation.

Deep Seismic Data

Deep Seismic Reflection Data in the Illinois Basin, *Heigold* A proposal to study deep seismic reflection data in the region of the intersection of the Reelfoot Rift and the Rough Creek Graben has been submitted to the National Science Foundation. The seismic data of interest consist of a new line across the Illinois Basin and the Reelfoot Rift acquired by the Consortium for Continental Reflection Profiling (COCORP), proprietary lines in the Reelfoot Rift

area acquired by the U.S.Geological Survey, and proprietary data acquired by the Illinois State Geological Survey. The purpose of this study is to provide an integrated geological and geophysical interpretation of the nature of the crust in a tectonically active portion of the Midcontinent.

Historic and Recent Earthquakes of Illinois, *Panno, Heigold, Krumm, Gaines, Harrison* Preliminary work involves the preparation of a video on epicenters of earthquakes that occurred between 1795 and 1988 in Illinois, as well as the examination of the clustering of earthquake epicenters both temporally and spatially in the state.

BASIN ANALYSIS

The Illinois Basin covers approximately 60,000 square miles in the southern two-thirds of Illinois and adjacent parts of Indiana and Kentucky. It contains about 100,000 cubic miles of sedimentary rocks with a wealth of resources including industrial minerals and metals, coal, and oil and gas. These resources have greatly benefited the economic health of Illinois for many years. Basin analysis, a multidisciplinary method of research, contributes to the continued discovery and development of mineral resources in Illinois.

The basin analysis program at the Illinois State Geological Survey integrates geological, geophysical, geochemical, and geotechnical data in order to understand better how the basin formed, filled with sediment, and changed after burial. The primary focus of research during the last reporting period was (1) construction of cross sections showing the structural and stratigraphic framework of the basin, (2) quantitative modeling to determine the mechanisms of tectonic subsidence in the Illinois basin, (3) stratigraphic analyses of selected Cambro-Ordovician rocks to determine facies relationships, (4) completion of a compendium on the structural features in Illinois, (5) conodont biostratigraphy of selected lower Paleozoic rock units, (6) correlation of Ordovician volcanic ash beds, and (7) completion of a reference volume on interior cratonic sag basins, principally the Illinois Basin.

To advance their research programs in basin analysis, the Illinois, Indiana, and Kentucky Geological Surveys formed an Illinois Basin Consortium (IBC) in April 1989. The mission is to carry out cooperative geoscience investigations and scientific exchanges that relate to problems and issues of basinwide interest. The goal of the consortium is to advance the understanding of the Illinois Basin and its resources and promote cooperative solution of basinwide problems. The Basinwide Cross-Section Program and a proposal to the U.S. Department of Energy Geoscience Institute on reservoir characterization are two recently implemented IBC projects. Joint projects on CUSMAP, correlation and mapping of coal beds, and a joint field trip are already underway. The IBC and the U.S. Geological Survey are also developing plans for a joint effort on an Illinois Basin study, part of the national effort to investigate evolution of sedimentary basin.s

Framework Studies

Illinois Basin Cross Section Project, *J. Treworgy, Whitaker, Pool, Finley, Desulis, Wilson* Construction of a grid of 20 regional cross sections that will cover the Illinois Basin, including adjacent areas of Indiana and Kentucky, is underway. The purpose of this cross-section network is to provide a better picture of the stratigraphic, structural, and paleoenvironmental framework of the Paleozoic section of the Illinois Basin. An improved perspective should help to generate new ideas that enhance the effectiveness of hydrocarbon and other mineral exploration in the basin.

During the report year, logs of approximately 120 wells in the 20 cross sections were digitized. Computer programs were written to transfer the digitized log data from the Prime computer to the newly acquired VAX computer. Preliminary correlations were completed for three cross sections. One section was displayed at the Illinois Oil and Gas Association Annual meeting. The project is being coordinated with geoscientists at the Indiana and Kentucky Geological Surveys to include their input on the cross sections that extend into these states.

Silurian Litho- and Biostratigraphy in Northeastern Illinois, *Mikulic, Norby* Exposures of Silurian rocks in northeastern Illinois are under study to establish a reference section that will aid in development of the aggregate resources of northern Illinois. The findings of this study will be used to extrapolate the litho- and biostratigraphy of the buried Silurian rocks that contain oil and gas reservoirs in southern Illinois.

From February to June of 1989, 106 cores, totaling about 45,000 feet, were logged. These cores, stored at the Metropolitan Sanitary District of Greater Chicago (MSDGC) warehouse in Skokie, represent a comprehensive coverage of the southern half of Cook County. Results of this logging include the discovery of Devonian-aged rocks at the bedrock surface along the Indiana border, descriptions of reef/interreef relationships of the Racine Dolomite, and refinement of the lithostratigraphic framework for Silurian rocks of the area.

Two MSDGC cores were processed for microfossils. Specimens recovered indicate the presence of four biostratigraphic zones that correlate to the biostratigraphic zones in the outcrop sections in northeastern Illinois and to other sections in the Midcontinent. This information will aid in developing aggregate resources in northern Illinois through a better understanding of the stratigraphy, regional correlation, and paleoenvironments of the Silurian rocks.

Silurian/Devonian Boundary in Southern Illinois, *Mikulic, Norby, Miller (Amoco Production Company)* The litho- and biostratigraphy across the Silurian/Devonian boundary in the White County deep core hole are being examined to determine the age, depositional environments, and character of the boundary in the deep portion of the Illinois Basin, and permit correlation from the deep basin to the basin margin where oil-producing reefs occur. Recovery of a variety of microfossils has allowed a more accurate age determination and redefinition of the boundary.

Structural Geology and Tectonic History

Structural Features of Illinois--An Encyclopedia, *Nelson* This major compendium, to be published as an Illinois State Geological Survey Bulletin, will be ready for administrative review early in the next reporting period.

Tectonic Subsidence History of the Illinois Basin, *J. Treworgy, Sargent, Kolata* In this study, tectonic subsidence in several deep wells of the Illinois Basin was quantitatively modeled to determine the mechanisms of basin formation. The information derived is fundamental to understanding how the basin formed, filled with sediment, and changed physically and chemically through time. Modeling included (1) decompacting the sediment fill through time to restore true sediment thicknesses at given times, and (2) backstripping stratigraphic units to remove the effects on subsidence due to sediment loading at given times so as to analyze tectonic events.

Initial results indicate that tectonic subsidence was controlled by three mechanisms: rifting, thermal subsidence, and an isostatically uncompensated mass in the lower crust. Decompaction and backstripping calculations will be performed on additional deep wells around the basin in an attempt to better understand the tectonic history of the Illinois Basin.

Glasford Meteorite Impact Structure, *Sargent, J. F. McHone, Jr. (Arizona State University)* Evidence of the positive gravity anomaly and the post-impact uplift of the Glasford Meteorite-Impact Structure was presented at the 1988 fall meeting of the American Geophysical Union. These factors are seen in a select group of impact structures; most have negative gravity anomalies and do not exhibit significant post-impact uplift. Glasford shows a +0.8 milligal residual gravity anomaly and more than 235 feet of cumulative post-impact uplift. The rate of uplift declined from more than 1.25 feet per million years during the Silurian Period to less than 0.5 feet per million years by mid-Pennsylvanian time.

Stratigraphy

Biostratigraphy of Marine Zones in the Lower Pennsylvanian of Southern Illinois, *Jacobson, Norby* Samples of marine strata collected from rock exposures and drill cores from the

Cooperative Geologic Mapping Program (COGEOMAP) project were analyzed for microfossils to obtain information on biostratigraphic zonation.

Tri-State Committee on Correlations in the Pennsylvanian System of the Illinois Basin, *Jacobson, Nelson, Damberger, Weibel, Peppers, staff of the Indiana and Kentucky Geological Surveys* During the past year, membership in the committee expanded to include geologists from the universities and coal-mining industry in the basin. Such broad representation will provide further insight and credibility to proposals for standardizing Pennsylvanian stratigraphic terminology, and assure broad consideration and peer review of correlations developed by the committee and on which the standardized terminology is to be based. The committee agreed on a proposed classification that divides the Pennsylvanian strata into Groups and Formations. The proposal will be recommended for official adoption by the Illinois, Indiana, and Kentucky Geological Surveys.

Common Stratigraphic Nomenclature for Formations and Groups for the Pennsylvanian System of the Illinois Basin, *Jacobson, Weibel, staff of the Illinois, Indiana, and Kentucky Geological Surveys* This paper represents a cooperative project between members of the Tri-State Committee on Correlations in the Pennsylvanian System of the Illinois Basin. A first draft includes recommendations for adoption of a common nomenclature for the stratigraphic classification of the Pennsylvanian strata into Groups and Formations. Standardized nomenclature will improve communication between researchers and industry geologists working on various aspects of the coal-bearing strata of the Pennsylvanian.

Lower Devonian Biostratigraphic Zonation, *Devera* Fieldwork conducted for COGEOMAP, the geologic mapping program in southern Illinois, has yielded several measured sections of lower Devonian strata on the Wolf Lake 7.5-minute quadrangle. Several hundred samples were taken for characterization of fossils. This work is continuing on the Cobden quadrangle. The purpose is to accurately zone the lower Devonian carbonate rocks of the Illinois Basin using conodonts and chitinozoans.

Biostratigraphy of the Strata Straddling the Mississippian-Pennsylvanian Boundary in Southern Illinois, *Weibel, Norby* The recent drilling of a core through the Mississippian Grove Church Shale created the opportunity to re-evaluate the biostratigraphy of strata at the boundary between the Mississippian and Pennsylvanian. Several recent studies on these strata, based on the investigation of outcrops, led to contradictory conclusions on the length of a hiatus at the contact between Mississippian and Pennsylvanian strata. Samples of the oldest Pennsylvanian Wayside Member of the Caseyville Formation and of the youngest Mississippian Grove Church Shale are being processed for extraction of microfossils. These fossils, primarily conodonts, will be used as a database for re-evaluating the biostratigraphy. Preliminary results will be presented during a symposium at the April 1990 meeting of the South-Central Section of the Geological Society of America in Oklahoma.

Conodont Biostratigraphy of the New Albany Shale, *Norby, Shaw (Queens College), Ettensohn (University of Kentucky)* An updated conodont biostratigraphy was formulated for the Upper Devonian/Lower Mississippian rocks of Kentucky (southeastern portion of the Illinois Basin). This new biostratigraphy will allow greater accuracy in correlating Upper Devonian rock units throughout the Illinois Basin. A final subcontract report was submitted in December 1988 to the National Science Foundation, which funded the project through the University of Kentucky. A summary paper was published in the proceedings of the Eastern Oil and Gas Shale Symposium at Lexington, Kentucky in November 1988. A paper on biostratigraphy was orally presented at the Geological Society of America North-Central meeting at Notre Dame in April 1989.

Correlation of the Ordovician Deicke and Millbrig K-bentonites Between the Mississippi Valley and the Southern Appalachians, *Huff, Kolata, J. Frost* Two widespread volcanic ash beds, the Deicke and Millbrig, can be correlated from southern Minnesota and northwestern Iowa through the Illinois Basin across Kentucky and central Tennessee to the Valley and Ridge of the

southern Appalachian Mountains. These beds cover approximately 500,000 square miles of eastern North America and represent useful time lines that provide a previously unattainable level of accuracy in Ordovician chronostratigraphy. These correlations enable accurate construction of structure maps and cross sections, as well as paleogeographic reconstructions used by oil companies, among others. A manuscript was prepared and submitted for publication in the Bulletin of the American Association of Petroleum Geologists. A grant by the National Science Foundation was awarded in June to continue this research project.

Sea-Level Changes in the Ordovician Champlainian and Cincinnatian Series of Illinois and Iowa, *Witzke (Iowa Geological Survey), Kolata* Recognition and correlation of genetic stratigraphic packages requires analysis of relative sea-level changes through time. Changes in sea level can be interpreted for any stratigraphic sequence at specific localities, but the problem remains as to whether these changes are due to local and/or regional structural influences or to fluctuations in global sea level. Only through broad-scale regional, interregional, and intercontinental correlations and stratigraphic analysis can the eustatic overprint be interpreted with confidence and an accurate picture be developed of the depositional and erosional history of an area.

A sea-level curve was constructed for the Middle and Upper Ordovician based on stratigraphic analysis of numerous outcrops in the Mississippi Valley region. A paper on this project was published in the Guidebook for the 18th Annual Field Conference of the Great Lakes Section of the Society of Economic Paleontologists and Mineralogists in October.

Facies Analysis of Ordovician Maquoketa, Galena, and Platteville Strata in Kane County, *Graese* This study documents the lithologic variability of Upper Ordovician and Silurian bedrock formations at and adjacent to the site proposed for the Superconducting Super Collider (SSC) in northeastern Illinois. Detailed facies analyses indicate paleostructural influences on deposition and diagenesis in Upper Ordovician and Silurian strata in northeastern Illinois. Paleostructure and topography, reflected in present-day structure of the top of the Trenton (Galena) surface, controlled subsequent thickness and distribution of Maquoketa carbonates in Kane County. The thickest carbonate rocks generally occur above present day structural highs partially reflecting paleohighs while shales and fine-grained carbonates occur along structural lows. Dolomitization of carbonate rocks is also concentrated along present-day and paleostructural highs. The final report will be published as an Illinois State Geological Survey Circular.

Lithofacies Mapping of the Eau Claire Formation in Illinois, *Sargent* The Eau Claire Formation is the equivalent of the Bonneterre Dolomite in Missouri, the host formation of hundreds of millions of tons of lead ore. Data on the thickness and rock types of the Eau Claire were compiled on a set of maps to help assess the potential occurrence of similar ore deposits in Illinois.

Geological features related to ore deposition in southeastern Missouri are also found in southern and western Illinois. Paleotopographic highs on the Precambrian surface have caused depositional pinchouts of parts of the Eau Claire Formation and the underlying Mt. Simon Sandstone. The carbonate beds of the Eau Claire range from entirely dolomite to entirely limestone. Ores are often found above pinchouts against Precambrian basement and at the boundary between limestone and dolomite. Preliminary results of this study will be published in two guidebooks: *Upper Cambrian Stratigraphy and Sedimentology of Southeastern Missouri*, from the Society of Economic Paleontologists and Mineralogists (SEPM); and *Regional Stratigraphy, Facies and Depositional Paleoenvironments in the Cambrian of Southern Missouri*, from the Geological Society of America.

Regional Stratigraphic Analysis, *Graese, Vaiden* Bedrock studies undertaken as part of the Superconducting Super Collider (SSC) siting investigations are being organized into an Illinois State Geological Survey Circular that includes detailed information on the Silurian, Maquoketa, Galena-Platteville, and Glenwood-St. Peter Sandstones. In addition to general work for the siting effort, a detailed facies analysis was undertaken to delineate potential minor structural anomalies not readily apparent from drill hole and seismic investigations. This report will be coordinated with

the seismic analysis of the area and provide the bedrock geologic framework for engineering, groundwater, and land-use planning purposes.

Paleoenvironmental Studies

Depositional Environments of the Lower Pennsylvanian Rocks Within the Illinois Basin, *Devera* A complex estuarine shoreline model has been developed to explain the nature of the lower Pennsylvanian marine sandstones in southern Illinois. The model was developed from data newly acquired from exposures, diamond drill cores, and subsurface geophysical data during geologic mapping in southern Illinois under the COGEOMAP program. Bedform geometry, primary sedimentary structures, and detailed paleontology of the Caseyville and lower Tradewater Formations provide ample evidence to support brackish to marine-dominated depositional systems during early Pennsylvanian time in southern Illinois. Previously, fluvial and upper to lower deltaic environments were thought to have been the principal depositional settings.

Synthesis

AAPG Interior Cratonic Sag Basins Volume, *Leighton, Kolata, Eidel, Oltz, staff* The Illinois State Geological Survey staff, working with geoscientists from the Indiana and Kentucky Geological Surveys as well as from academia and industry, are compiling one of five volumes in the World Petroleum Basin Series to be published by the American Association of Petroleum Geologists (AAPG). This series will present a broad overview of fundamental basin types, basin evolution, oil and gas plays, and distribution and size of oil and gas fields. Compilation of this volume is generating insights into the geology, geophysics, and geochemistry of the Illinois Basin. Knowledge gained will help guide future investigations of the mineral resources in Illinois.

During this reporting period, most manuscripts reached the final revision stage. A major task, the volume will consist of more than 600 pages of discussion and 565 illustrations; it will be a standard reference on the Illinois Basin with chapters comparing similar basins around the world. The entire manuscript is scheduled to be submitted to AAPG by December 1, 1989; publication will take place in June 1990.

Training and Information Exchange

Current Aspects of Basin Analysis and Sedimentary Geology The Illinois State Geological Survey sponsored a workshop presented by Dr. George de V. Klein of the University of Illinois, Department of Geology, on December 15 and 16, 1988. The workshop was attended by 22 Survey geoscientists, one geologist from the University of Kentucky, and three geologists from the Indiana Geological Survey. Course material included an overview of the interacting fields of basin analysis and sedimentary geology with a focus on how geodynamic processes of basin formation influence both the nature of sediment fills, and the maturation of the sediment through diagenesis, fluid circulation, and thermal history. The workshop incorporated basin analyses from the Illinois Basin and the North Sea.

Seismic Stratigraphy Workshop This workshop was held at the Survey from June 5 to 9, 1989, and was attended by 17 Survey geoscientists and one geologist each from the Kentucky Geological Survey, U.S. Geological Survey, and University of Illinois. The course was taught by Dr. Robert Mitchum, formerly with the Exxon Production Research team that developed the basic concepts of seismic stratigraphy. Seismic stratigraphy concepts were covered in the initial sessions of the workshop, then examples of seismic reflection data and wireline logs from Illinois were evaluated and interpreted. The workshop provided hands-on experience in modern stratigraphic analysis that directly applies to several ongoing projects at the Survey.

Technology Transfer

Kentland Structural Anomaly Field Trip, Technology Transfer, and Information, *Rydin (Purdue University), Schultz (Goddard Space Center), Pavlis, Sargent* A field trip to examine the Kentland Structural Anomaly just east of Sheldon in Iroquois County, Illinois, was conducted together with the annual meeting of the North-Central Section of the Geological Society of

America held at Notre Dame, Indiana. Intense deformation in an area characterized by nearly flat-lying strata shatter cones in a variety of rocks, and syndeformation injection breccias suggest the structure was caused by meteorite impact. Observing these features in a structure exhumed by quarrying provides a useful analog to impact structures near Peoria and Chicago, Illinois, which are buried by as much as 1,100 feet of postimpact deposits.

GEOLOGIC AND TOPOGRAPHIC MAPPING AND REMOTE SENSING

Geologic Mapping

Cooperative Geologic Mapping Program with the U.S. Geological Survey (COGEOMAP), *Damberger, Nelson, Jacobson, Devera, Weibel, Peppers, DeMaris* Significant progress was made towards completing the geologic mapping of fifteen 7.5-minute quadrangles in southern Illinois. The cooperative agreement with the U.S. Geological Survey to map these quadrangles was extended for the fifth year. The current agreement extends to November 15, 1989, and support is being sought for an additional year.

The main goal of the project is to produce detailed geologic maps (scale 1: 24,000) and accompanying reports for an area in southern Illinois in which the lower Pennsylvanian coal-bearing sequence of rocks crops out in an east-west belt representing the closure of the Illinois Basin. This area had never been mapped in detail nor have its coal resources been fully assessed. During the report period the following work was performed:

- **Geologic Map of the Creal Springs Quadrangle**, *Trask, Jacobson* The Cartographic Laboratory of Northern Illinois University (NIU) nearly completed its work for producing the four basic color negatives needed by the printer.

- **Geologic Maps of the Eddyville and Stonefort Quadrangles**, *Nelson, Lumm* Final drafts were completed and delivered to NIU's Cartographic Laboratory for preparation of the four basic color negatives.

- **Geologic Map of the Waltersburg Quadrangle**, *Weibel, Nelson* The map is being revised on the basis of comments received from reviewers at the Illinois Geological Survey and C. Rice of the U.S. Geological Survey.

- **Geologic Map of the Goreville Quadrangle**, *Jacobson, Damberger* The final draft for this map was completed, reviewed by team members, and submitted for review to C. Rice of the U.S. Geological Survey.

- **Geologic Map of the Glendale Quadrangle,** *Devera* A draft of this map was completed and reviewed internally and by C. Rice of the U.S. Geological Survey. It is now being readied for preparation of the scribecoats and the four basic color negatives by NIU's Cartographic Laboratory.

- **Geologic Map of the Makanda Quadrangle**, *Weibel, Jacobson, Damberger* Field work was initiated in this quadrangle, and approximately two-thirds of the quandrangle has been mapped.

- **Geologic Map of the Cobden Quadrangle**, *Devera, Nelson, Jacobson* Significant progress was made mapping this quadrangle during the last field season of 1988-89.

- **Geologic Map of the Bloomfield Quadrangle**, *Nelson* Preliminary drafts of the geologic map and report were completed. This quadrangle is not part of the original agreement with the U.S. Geological Survey and was put on hold.

- **Geologic Map of the Wolf Lake Quadrangle,** *Devera* Mapping of the bedrock geology has been was completed. A draft map is now being compiled on a greenline mylar topographic base map; it should be ready for internal review in the fall of 1989.

• **Geologic Map of the Gorham Quadrangle**, *Devera* Field work began during the spring of 1989 and will continue in the fall/winter field season of 1989-90.

• **Geologic Map of the Lick Creek Quadrangle**, *Weibel, Nelson* Field data were collected from the entire Lick Creek Quadrangle. First drafts of the geological map and cross sections were started near the end of the report period.

• **Geologic Report on the Creal Springs, Eddyville, and Stonefort Quadrangles,** *Nelson, Jacobson, Trask, Devera, Riggs, Follmer (Illinois State Geological Survey); Esling, Lamon, Henderson (Southern Illinois University)* Parts of the report were rewritten to respond to reviewers' suggestions. The Survey's review will be completed early in the next report period.

• **Geologic Report on the Goreville Quadrangle,** *Jacobson* A draft of the manuscript was completed, reviewed internally, and submitted to the U.S. Geological Survey for review.

• **Geologic Report on the Waltersburg Quadrangle,** *Weibel, Nelson* The final draft of the report to accompany the geologic map of the Waltersburg Quadrangle is near completion.

• **Geologic Report on the Glendale Quadrangle,** *Devera* The manuscript describing the bedrock geology of the Glendale geologic quadrangle was nearly completed; plates and figures are currently being drafted.

• **Geologic Report on the Wolf Lake Quadrangle,** *Devera* Work on this manuscript began near the end of the report period.

• **Diamond Core Drill Program,** *Damberger, Jacobson, Nelson, Weibel, DeMaris* A stratigraphic test well was drilled in the Makanda Quadrangle to obtain a core of the Caseyville Formation. The formation is thinner than usual in that area. Rock exposures are smaller and not as common as in other mapped areas.

Remote Sensing

Introduction to Remote Sensing Short Course, *Stohr* Two sessions of this course were taught at the 31st Annual Association of Engineering Geology Meeting in Kansas City, Missouri. Ten geologists and engineers participated in the one-day course, which included a video of thermal infrared for aerial reconnaissance, field, and laboratory applications. The video, prepared from previous site investigations, included a segment demonstrating how quantitative thermal measurements are made directly from the scanner.

Symposium on Remote Sensing and Its Applications, *Stohr* The Illinois Mapping Advisory Committee (IMAC) held a "Symposium on Remote Sensing and Its Applications" at the Illinois State Geological Survey on January 20, 1988. About 60 people attended the symposium, which consisted of 12 papers by researchers from Illinois, Indiana, and Kentucky. IMAC Secretary Stohr organized the symposium.

QUATERNARY INVESTIGATIONS

Establishment of Quaternary Framework Studies Section

As a part of the reorganization of the Illinois Geological Survey effective November 1, 1988, the Quaternary Framework Studies Section was established within the Environmental Geology and Geochemistry Branch, with John P. Kempton, previously leader of the Superconducting Super Collider Geological Task Force, named as section head.

The Geological Survey has a long and distinguished history of Quaternary Studies and is recognized nationally and internationally for leadership in the studies of glacial sediments. Leadership for this work came from two former Chiefs, M. M. Leighton and his successor, John C. Frye, both working with H. B. Willman, head of the Stratigraphy and Areal Geology Section for

many years. Through the years, many other Survey staff have also contributed significantly to the understanding of the state's Quaternary deposits. During the past 15 years, Quaternary research conducted by staff of the various sections as a part of their programs, has been coordinated by Quaternary specialists in the Stratigraphy and Areal Geology Section and a Quaternary Geology Committee.

The first tasks undertaken by the new section were to (1) develop a mission statement; (2) review all current studies and activities to determine priorities; (3) develop coordination among all Quaternary workers and projects; (4) identify unfinished projects and obtain support for completing those that have merit; (5) review activities and proposals of the Quaternary Committee; (6) develop procedures for identifying, inventorying, and displaying Key Quaternary Stratigraphic Control throughout the state; (7) develop a program of basic Quaternary data collection and research that will continue to provide a fundamental understanding of Quaternary deposits and the information needed for related applied studies; and (8) integrate Quaternary research with a cross-section and mapping program.

Framework Studies

Quaternary History and Stratigraphy, Northeastern Illinois, *Hansel, W. H. Johnson (University of Illinois)* A study of the age, stratigraphic position, and significance of the Lemont drift, a distinctive glacigenic unit in northeastern Illinois, was reported in the *Journal of Geology*. Implications for revision of lithostratigraphic classification in northeastern Illinois are significant.

Key Stratigraphic Control, *Kempton, Hannah* Initiated in December 1988 as part of the final work on the Superconducting Super Collider (SSC) siting study, the project to define key stratigraphic control was viewed as a documentation and quality control effort to assure adequate cataloging, evaluation, and archiving of all data on Quaternary deposits collected and/or utilized during the SSC project. Early development of the project disclosed important implications, not only for quality control but also for mapping of the Quaternary geology of the area and the remainder of the state. Key stratigraphic control of the entire state is now a key objective of the Quaternary Framework Studies Section.

Surficial Geology of the Creal Springs, Stonefort, and Eddyville Quadrangles, *Riggs, Follmer; Esling, Henderson, and Lannon (Southern Illinois University)* Relatively soft nonlithified Quaternary-age materials represent a major unconformity resting on the Paleozoic bedrock in the Creal Springs, Stonefort, and Eddyville Quadrangles in southern Illinois. These surficial deposits were evaluated in detail as part of a cooperative project between the Illinois Geological Survey and the Department of Geology, Southern Illinois University in Carbondale. The project is part of the COGEOMAP mapping program of the U.S. Geological Survey. The main purpose of this study was to produce a detailed map of the Quaternary deposits found within the three quadrangles to accompany the bedrock geologic maps prepared by the Illinois Geological Survey.

Quaternary Environments and Processes

Glacigenic Lithofacies and Sequence Studies, *Hansel, W. H. Johnson (University of Illinois)* Classic glacigenic sections in northeastern Illinois are being reexamined to identify (1) the major lithofacies associations (inferred to represent distinct environments of deposition), and (2) glacigenic sequences (proglacial fluvial and lacustrine sediments, subglacial till and fluvial deposits, and supraglacial and ice-marginal sediment flow, fluvial and lacustrine deposits), which tend to be remarkably complete in northeastern Illinois. Better understanding of lithofacies associations in glacigenic sequences makes it easier to predict probable relationships among glacial materials in northeastern Illinois. Increased knowledge of the geometry and genesis of lithofacies has impact and applications in groundwater studies, land-use planning, prediction of engineering properties for construction, and siting landfills. The study on the glacigenic sequence at Wedron, Illinois, will be reported in the *Journal of Sedimentary Petrology*.

Subglacial Processes and Sedimentation Studies, *Hansel, P. U. Clark (Oregon State University)* Because subglacial processes in the modern environment are generally inaccessible

for observation, examination of well-preserved features from the Quaternary record that indicate clast ploughing, lodgement, and glacier sliding over a soft bed is important to increase understanding of subglacial processes and sedimentation. This study will be reported in Boreas.

Field Evaluation of Deformable Bed Model, *Hansel, W. H. Johnson (University of Illinois), Clark (Oregon State University)* A critical research objective in glacial geology is to identify to what extent, if any, deforming beds controlled the dynamics of large Pleistocene ice sheets in North America and Europe. The upper Wisconsinan deposits of the Lake Michigan Lobe in Illinois are being examined for evidence of extensive deformable beds at the margin of the Laurentide Ice Sheet during the Quaternary because (1) reconstructions of the ice-sheet profile suggest glacier movement by sub-ice deformation of the substrate or basal sliding rather than by deformation in the ice, and (2) preliminary field study of glacigenic deposits is consistent with evidence indicative of deformable beds, as suggested on theoretical grounds. The existence of deforming beds has significant implications for understanding and modeling the dynamics of large ice sheets. A research proposal requesting 2 years of funding for this study was submitted to the National Science Foundation in June 1989.

Technology Transfer and Information Services

Quaternary Framework of the Lake Calumet Area, *Hansel, Kempton, Miller* At the request of and supported by the Illinois State Water Survey, the Quaternary Framework Studies Section has agreed to contribute basic geologic information to the first part of a plan for comprehensive evaluation of the occurrence, transport, and fate of groundwater contaminants in the Lake Calumet area of southeastern Chicago. The geologic framework, including appropriate maps and cross sections of the Quaternary deposits and the bedrock surface, will be provided. Also to be provided is an evaluation of the adequacy of the existing geologic database and recommended areas where additional geologic data are needed to more adequately define the geologic framework for attaining the overall objectives of the plan.

PALEONTOLOGY/PALYNOLOGY INVESTIGATIONS

Paleontology/Palynology Investigations focus on the use of information from fossils to date rock units, correlate rock units, determine the environments of deposition of the rock, and determine the evolution and relationships of fossil groups. One paleontology study focused on the relationships of a Mississippian microfossil and its value in correlating strata. Another study involved using trace fossils (marks made by ancient plants or animals which are now preserved in the rock) to determine that some Pennsylvanian rock units were of marine origins rather than deltaic or nonmarine, as previously believed.

Palynology, the study of fossil spores and pollen, aids in correlating the lower Pennsylvanian strata that are being mapped in southern Illinois as part of COGEOMAP and correlating Illinois Basin rocks worldwide.

Paleontology Studies

Ichnofossil Research in the Illinois Basin, *Devera* Fossil traces of invertebrates have contributed to a better understanding of the origin of upper Mississippian and lower Pennsylvanian rocks in southern Illinois. Previously unknown trace fossils have been discovered. A new shrimp(?) resting trace is currently being named with the help of Dr. Fredrick Schram of the San Diego Natural History Museum. The type specimens will be deposited within the trace fossil collection at the Illinois Geological Survey.

A manuscript on trace fossils, completed during the report period, will provide background for a 2-hour workshop to be held in New Harmony, Indiana, in conjunction with a field trip during the Geological Society of America Annual Meeting in St. Louis in November 1989.

Paleontologic Catalog for Fossil Collections, *Jacobson* Work was completed on a computerized fossil catalog application using Hypercard on an Apple Macintosh personal computer. The catalog was developed for fossils collected through years of Survey work. The

program is being considered for curating the Survey's fossil collections. In developing the application, input was solicited from members of the Paleontologic Research Committee.

Taxonomic Study and Biostratigraphic Significance of the Mississippian Conodont Genus *Lochriea*, *Von Bitter (Royal Ontario Museum), Norby* This study redefines the Mississippian conodont genus *Lochriea* and makes it more useful as a biostratigraphic indicator. Several species, which now will be classified under this genus, have become very important in several international biostratigraphic charts. These species, however, were not well understood because the constituent elements of each species had been misidentified. The study is completed and a manuscript is being prepared for publication in the *Journal of Paleontology*.

Paleocene Foraminifera from Southern Illinois: Biostratigraphy and Paleontology, *Fluegeman (Ball State University), Masters* The Upper Clayton Formation (Paleocene) from Mounds in Pulaski County, Illinois, was found to contain an abundant, well-preserved, benthic foraminiferal fauna and rare planktonic forms. The planktonic foraminiferids indicate assignment to the *Subbotina pseudobulloides* Zone. The benthic assemblages all indicate open marine conditions and water depths of less than 20 meters. The Mounds locality is the fourth in the Upper Mississippi Embayment to yield abundant foraminifera from the Clayton and the first to be studied quantitatively, providing a biostratigraphic and paleoecological standard for future investigations in the region. The study was presented in poster format at the Annual Midyear Meeting of the Society of Economic Mineralogists and Paleontolgist, August 21-24, 1988, at Columbus, Ohio.

Palynology Studies

Correlation of the Hymera and Danville Coal Beds in Southeastern Indiana with Coals in Illinois, *Peppers* Several core samples of the Danville and Hymera Coals from southeastern Indiana were submitted by the Peabody Coal Company to determine the relationship between the Hymera Coal and coals in Illinois. The Hymera lies between the Herrin and Danville Coals of Indiana, and may be equivalent to the Jamestown Coal of Illinois. The study did not resolve this problem because the spore assemblages in the coals are not diverse or distinctive. However, the Danville Coal of southern Indiana appears to be slightly younger than the Danville Coal of eastern Illinois and may be correlative with the Allenby Coal of Illinois or No. 13 Coal of western-central Kentucky.

Palynological Correlation of Major Pennsylvanian (Upper Carboniferous) Chronostratigraphic Boundaries in Euramerica, *Peppers* New information is being added to this long-term project, which is in revision following review. The report will be submitted to an outside journal.

Subcommissions of the International Commission on Carboniferous Stratigraphy on the Middle Pennsylvanian and on the Pennsylvanian, *Peppers* A report summarizing important palynological events, especially at the Pennsylvanian series boundaries, was prepared for the chairmen of the Middle Pennsylvanian Subcommission and the Pennsylvanian Subcommission. These data will be added to recommendations presented by other paleontologists for defining Pennsylvanian chronostratigraphic boundaries. Discussions will be held at Provo, Utah, in September 1989, and recommendations will be made on what criteria will be used for identifying the boundaries. The Middle Pennsylvanian Subcommission is recommending that their stratotype should be established in the western part of the Midcontinent where cylic deposits include nonmarine shale containing plant compressions and spores, coal with spores, and strata containing marine fossils. Correlation with the Illinois Basin would be relatively easy compared to other recommended stratotypes in Nevada, which is exclusively marine, and in West Virginia, which is almost totally nonmarine.

Midcontinent Pennsylvanian Working Group of the Society of Economic Paleontologist and Mineralogists (SEPM), *Peppers* This group is concerned with Pennsylvanian stratigraphy, especially its cyclic nature, boundary problems, and correlations with other regions including the Illinois Basin. Coal samples collected during its 1988 spring field trip in Kansas and Oklahoma were analysed and correlated, and a report was sent to members of the Working Group. Of

particular interest was identification of the upper and lower boundaries of the Middle Pennsylvanian. These studies are also providing information on stratigraphic correlations between the Midcontinent and the Illinois Basin. The lower part of the Middle Pennsylvanian in the Midcontinent is younger, as correlated with the Illinois Basin, than earlier thought.

A sample from a coal in Iowa considered equivalent to the Rock Island Coal of Illinois was submitted for identification. Palynology indicates that it is younger than the Rock Island Coal. A fusulinid species that is used to identify the base of the Desmoinesian was first described from the overlying limestone. Thus, the stratigraphic range of the species should be examined. Several other coal samples that were submitted by members of the Working Group were examined to help provide correlations within the Midcontinent and with the Illinois Basin.

Palynology of the Middle-Upper Pennsylvanian Boundary in General, *Peppers* The marked change in coal swamp vegetation at the Middle-Upper Pennsylvanian boundary is well known and probably occurs worldwide. It is not known whether the change can be detected in clastic rocks between the boundary coals. Several stratigraphic sections in Ohio, Illinois, and Kansas have been tested, but two sections in Kansas are the only ones found that include strata containing spores between coals. One section contains Middle Pennsylvanian assemblages in shale up to the base of the lowest Upper Pennsylvanian coal. Another section displays a change at about the middle of the section between the oldest Middle and youngest Upper Pennsylvanian Coal. This zone is apparently a few feet below the level at which there is a change in marine fossil assemblages. The section was sampled in 1-foot increments or less to find the precise stratum at which the change occurs. Rock samples at the boundary of change may also yield clues that can help explain the cause of the biological changes.

Palynologic Correlations for Cooperative Geologic Mapping Project (COGEOMAP), *Peppers* Eighteen Lower and lower Middle Pennsylvanian coal samples from Pope and Williamson Counties were studied for their spore content to determine their ages and to assist the mappers in their correlations of strata.

Technology Transfer and Information

Management of the Paleontological Collections, *Norby* Eleven loans of fossil material (many from the "Worthen Collection") were made to researchers from eight academic institutions in the United States, Canada, and Germany. Six previous loans were returned. A start was made on assembling locality information on some of the microfossil collections.

GEOCHEMICAL INVESTIGATIONS

Shale Geochemistry

Organic Geochemistry of the Anna and Energy Shale Members of the Carbondale Formation (Pennsylvanian), Illinois Basin, *M. Chou, C.-L. Chou, Dickerson, Kruge (Southern Illinois University)* The sulfur content in the Herrin No. 6 Coal of Illinois has been shown to be related to the sedimentary environments of roof strata. Coal that is overlain by relatively thick nonmarine gray Energy Shale has a lower sulfur content than does coal that is overlain by marine strata of the Anna Shale and Brereton Limestone. The purpose of this project is to provide new organic geochemical data on coal and coal related strata. Data obtained will be used to understand and better predict changes in sulfur content.

Biomarkers in extracts from Anna Shale samples are being studied using gas chromatography/mass spectrometry analyses. A preliminary qualitative comparison of hopanes, tricyclic terpanes, and steranes indicates a north versus south distinction. Samples from the northern coal mines have relatively high hopane C_{30}/C_{29} ratios, are low in tricyclic terpanes, and have steranes with C_{29} greater than C_{28}. Conversely, samples from the southern coal mines have relatively low hopane C_{30}/C_{29} ratios, are very high in tricyclic terpanes, and have steranes with C_{29} less than C_{28}. This project was temporarily suspended because of other commitments.

Geochemical and Petrologic Features of Phosphate Nodules in Paleozoic Midwestern Black Shales, *C.-L. Chou, J. Frost, Shaffer (Indiana Geological Survey), Coveney (University of Missouri at Kansas City)* The purpose of this project is to study the mineralogy and geochemistry of discrete phosphate nodules in black shales of Devonian-Mississippian and Pennsylvanian ages in the midwestern United States. Twenty-four phosphate nodules from the New Albany Shale and six from Pennsylvanian shales were analyzed for mineralogy and trace elements. These samples are composed mainly of carbonate fluorapatite and enriched in several trace elements. Zinc and uranium are abundant. Rare earth element patterns, normalized to shales, showed negative cerium and slightly positive europium anomalies. Phosphate nodules formed during the diagenesis of the black shales. Trace elements were incorporated into the nodules during their formation. This work was presented at the Geological Society of America meeting, October 31 to November 3, 1988, in Denver, Colorado.

Biogeochemistry

Kinetic Isotope Effects Associated with Fermentation Derived Acetate and Relationships to Sedimentary Biogenic Methane, *Risatti* This joint project with scientists from Indiana University has the objective of understanding the flow of carbon and the role of biogenic acetate in anaerobic sediments in which biogenic methane is formed. Our portion of the laboratory work for this project was completed in FY88 and the results were summarized in last year's report. One manuscript presenting the results of this work was accepted by the journal, *Organic Geochemistry.*

Geochemistry of Natural Gas, *Riley, Coleman, Liu* Natural gas samples collected as part of our oil, gas, and water well testing programs, along with samples submitted by individuals and industry, are analyzed to determine their chemical (and sometimes isotopic) compositions. This information adds to our basic database on the geochemistry of natural gas in Illinois. This information is used frequently to distinguish gases from different sources and help solve production and environmental problems. During the reporting period, 59 natural gas samples were analyzed and 28 natural gas wells were flow-tested.

In March, at the request of the Du Page County Forest Preserve District gas samples were collected from selected monitoring wells located around a landfill to determine if the gas present was coming from the landfill or from another source. Stable isotope and radiocarbon analysis of the samples indicated that the gas had originated in the landfill. In June, we responded to a request for assistance from the Springfield Fire Department to determine the source of high methane concentrations observed in the sewer system in one area of the city. Several possible sources were considered: (1) gas generated by the bacterial decomposition of organic material (normal sewer gas), (2) gas from a nearby abandoned coal mine, or (3) leakage from a natural gas pipeline. Analysis of samples collected from the area indicated that it was pipeline gas.

Coal Geochemistry

Geochemistry of Sulfur in Coal, *C.-L. Chou* The geochemistry of sulfur in fossil fuels was the theme of a symposium sponsored by the Division of Geochemistry at the 197th National Meeting of the American Chemical Society in Dallas, Texas, April 9-14, 1989. A paper on the geochemistry of sulfur in coal summarized current understanding of the origin and distribution of the various forms of sulfur and sulfur-containing organic compounds in coal, as well as the relationships between the compositional characteristics and geologic conditions of coal formation. The paper will be published in the proceedings.

Geological Society of America (GSA) Special Paper on Recent Advances in Coal Geochemistry, *C.-L. Chou, L. L. Chyi (University of Akron)* Recent research on the geochemistry of peat and coal is the focus of a forthcoming Geological Society of America publication (Special Paper 248) that includes papers presented at a recent GSA symposium on this topic.

Trace Element Geochemistry of Coal Using the Synchrotron X-ray Fluoresence Microprobe of Brookhaven National Laboratory (BNL), *C.-L. Chou* Trace element geochemistry provides valuable information about the conditions of coal formation that control the quality of coal.

Because of its excellent resolution and sensitivity, a synchrotron XRF microprobe permits determination of trace elements in minute areas of about 20 x 20 micrometers. Initial results show that pyrite in Illinois coal is enriched in arsenic, selenium, lead and thallium. A poster paper on the topic was given cooperatively with scientists of the BNL at the American Geophysical Union meeting in Baltimore, Maryland, May 7-12, 1989.

MINERALOGIC INVESTIGATIONS

With "Build Illinois" support and contractual and general revenue funds (GRF), the Illinois State Geological Survey continues to maintain a world-class laboratory for mineral studies. This laboratory assists the Illinois Department of Energy and Natural Resources and state scientists, and students and staff from state universities and colleges. The laboratory supports a broad range of projects within the Survey. Mineralogical analyses are used to tell landowners whether their earth materials have value as industrial products, identify changes in raw materials that disrupt the State's mineral industries, and contribute to the solution of environmental problems such as waste disposal studies. Clay analyses recently have shown that "pipestone" used and traded by Native Americans near Sterling has an unique composition and may be traceable throughout ancient Indian trade networks of various ages. The laboratory provided identification of harmless materials stored at an abandoned hazardous waste site in Chicago, which reduced handling and disposal requirements for Illinois Environmental Protection Agency.

The research aspect of mineralogical investigations includes studies of clay minerals in soils that (1) help to reconstruct the paleogeography and climate during ancient times of soil formation, (2) predict the suitability or capacity of materials for the isolation or absorption of hazardous wastes, (3) indicate areas of geotechnical hazard or increased stability, and (4) can be used to evaluate soils for clay products, crop substrates, or pond liners. The first question asked about a candidate landfill or hazardous waste site is the nature of Quaternary rock units. Most studies at sites such as the proposed Martinsville low-level nuclear waste site are designed to extend existing regional frameworks that are partly the result of earlier mineralogical investigations. The detailed structure of illite (a widespread clay mineral named at the Survey after the state of Illinois) and the clay mineral, chlorite, are believed to reflect the passage of solution of varying compositions and to control fluid flow behavior. These are a few examples of the many ways in which mineralogical investigations serve Illinois.

Soil Clays, *Hughes, Moore, Glass* Studies of the mineralogical composition of soil is yielding knowledge of soil-forming processes that cause distinctive changes in soil mineralogy. The purpose of the study is to identify mineralogical "signatures" indicative of types of soil formation. New samples containing poorly crystallized kaolinite and mixed-layer kaolinite/smectite (K/S), were located. Preliminary studies of the genetic relationship between low- and high-charge vermiculite, smectite, and illite/smectite in weathering profiles were conducted. Although still thought of as rare, K/S has been found in fossil soils of various ages in Illinois. It has also been shown that ballclay kaolins contain small amounts of K/S, and that most ballclays may have originated by weathering of montmorillonite, especially in the Porters Creek and the McNairy Formations of southern Illinois.

XRD Method to Differentiate Detrital from Diagenetic Illite, *Hughes, Moore, Crockett, Seyler, Glass, Austin* Development continued on a method to differentiate detrital from diagenetic illite. This method helps to identify the potential of an argillaceous rock unit to produce diagenetic water that may help to transport oil to reservoirs. The method also aids in the resolution of several other geological problems because detrital and provenance effects can be distinguished from post-burial alteration. Further investigations resulted in a quantitative method to estimate the relative proportions of detrital and diagenetic forms of illite. A poster paper was presented by Hughes, Moore, Austin and Glass, and an article was published by Austin, Glass, and Hughes on the identification of illite polytypes in clays and clay minerals.

Mineralogy, Mixed-Layered Compositions, and Illite Polytypes of Paleozoic Rocks of Illinois, *Moore, Hughes, Glass* Developing special sample-preparation techniques for recognizing and measuring polytypes (structural types) of illitic materials is the current focus, including an effort to define postdepositional environments and diagenetic histories of sedimentary rocks. New samples were collected to further studies of the St. Peter, Aux Vases, Maquoketa Group, and New Albany units.

Quaternary Geology by Mineral Composition, *Glass, Moore, Hughes* The mineral composition of Quaternary deposits and soils developed within these deposits is being used to reconstruct their history. Work continued this year to develop methods for recalculating results from weathered samples for comparison with unweathered materials. Several students were also assisted with thesis studies in this area, and efforts were expanded to ensure the collection of statistically valid analyses and establish reliable procedures for quality assurance and control.

Mineralogy of Chlorites, *Moore, Hughes, Glass* This group of minerals is intimately involved in determining porosity and permeability in petroleum reservoir rocks and often is the most important reactant to fluids introduced into the reservoir by man. Also, this group holds the potential for indicating a great deal of information about depositional, diagenetic, and weathering conditions in glacial and clastic rocks.

Mineral Identification of Clays from Acid-Insoluble Residues, *Moore, Hughes* The fine material from the insoluble residues prepared for this study were retained and samples were prepared as oriented aggregates; X-ray diffraction tracings were then made of the air-dried and ethylene-glycol-solvated states. The tracings were interpreted to identify minerals and their approximate proportions. The individual 10-foot-interval samples are currently being combined into sets representing formations for more refined investigations.

XRD Laboratory Improvements for Mineral Analysis

Manual for the X-Ray Lab, *Moore, Wilson* The goal is to produce a manual that will provide (1) a user-friendly guide to the use of the machines in the X-ray Lab; (2) descriptions of standard methods of sample preparation; and (3) information necessary for the service and maintenance of the equipment in the X-ray laboratory. The manual is approximately half finished.

Quality Control in Clay Sample Preparation, *Moore, Hughes, Glass* Progress was made in establishing quality-control standards for the operation of the X-ray diffraction laboratory. Variances measured include those within a given sample preparation and among preparations, from a single machine and among machines, and among operators, interpreter of a given data set, and types of interpretations. Blind duplicate analyses of at least 10 percent of each sample set has also become the standard for quality assurance and quality control (QA/QC) in this area. Procedures for QA/QC are in preparation as part of the Survey's overall effort to establish QA/QC procedures.

X-Ray Diffraction and the Identification and Analysis of Clay Minerals, *Moore, Reynolds (Oxford University Press)* Publication date is September 15, 1989. This book was prepared to fill the need for a modern textbook on clay mineralogy. Reynolds is on the faculty at Dartmouth College, Hanover, New Hampshire.

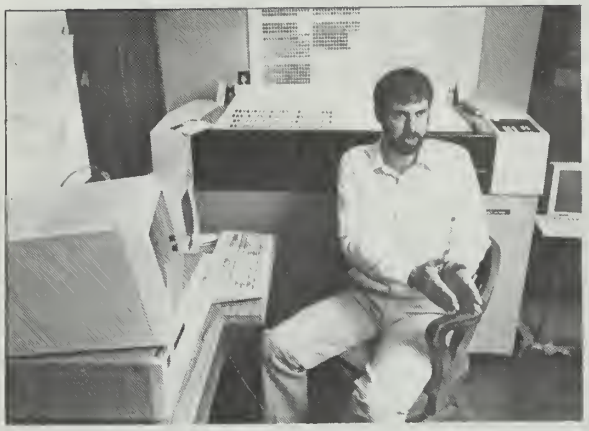
X-ray Diffraction, Identification, and Analysis Report, *Hughes* A report on the value of X-ray diffraction for evaluating industrial minerals deposits and mineral-processing methods was prepared by Hughes and Warren for publication in the Proceedings of the 23rd Forum on the Geology of Industrial Minerals.

COMPUTER RESEARCH

Programming and Data Entry Research

ARCPLOT MENU Program, *Pool* A program was written for easier access to the Geographic Information System (GIS) of the Illinois Department of Energy and Natural Resources. The

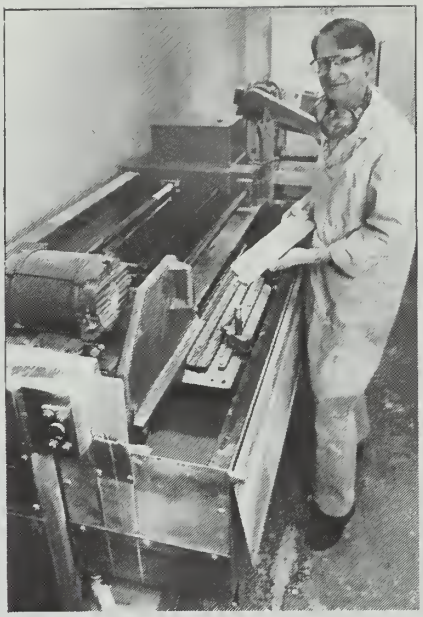
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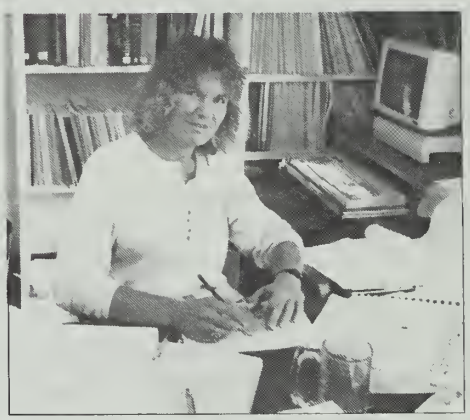
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(A) Stephen Whitaker, Oil and Gas Section, explains that he is retrieving coordinates from the Prime computer to combine with a base map on the new VAX computer. These interpretive maps are printed out in color on the 40-inch CalComp electrostatic plotter in the background. (B) Jim Jennings, Lake Michigan Coast and Basin Studies Section, and Dave Cooley, Technical Design, Operations, and Maintenance, examine the fossil of a lycopod tree stump, now displayed in the ISGS lobby. (C) Rodney Norby, Basin and Crustal Analysis Section, operates a core slabbing machine as part of the process of separating microfossils from rock core. (D) Ardith Hansel, Quaternary Framework Studies Section, works on time classifications for the Quaternary Epoch. (E) Joyce Frost, Analytical Chemistry Section, constructs a lead cave for handling radioactive samples of geologic materials that have been irradiated to measure elements in them.

program is a popular tool, used by several sections of the Survey because it solves some of the more difficult ARCPLOT problems usually encountered and allows new users to create a map after only a couple of hours of training.

WELLOG Program, *Pool* The WELLOG program provides utilities for digitizing and displaying wireline logs using ARC/INFO. It features easy-to-use, pull-down menus and has been used extensively this past year by the Basin Analysis Task Force in the creation of log-based cross sections with variable vertical and horizontal scales and a user-selected datum.

Missing Items List, *Denhart* In cooperation with the Geological Records Unit, the Computer Research and Services Section has written a program to list all oil and gas drillers who have drilled wells in the state but have not submitted the required logs and records to the Survey. The program has identified almost 6,000 wells that are missing some piece of information. This list was requested by members of the Illinois Geological Society and the Illinois Department of Mines and Minerals. Granting of drilling permits will not be allowed to individuals who are not in compliance with reporting requirements.

Technology Assessment

Investigation of ARC/INFO Output for Map Publication, *Wilson, McKay* Methods of producing color transparencies directly from ARC/INFO for color printing in Survey publications have been tested in a project with the Natural History Survey. These techniques, utilizing Postscript output to a Linotype typesetter, may be more cost effective than traditional methods in some situations.

Automated Maps for On-Demand Printing and Publication, *McKay, Krumm, Wolf, Stiff, Krick* A team of staff members from Publications, the Library, and the Computer Section visited the Kansas Geological Survey (KGS) to learn about its efforts in inhouse mapping and printing. During the 2-day visit, Illinois Survey staff talked to Kansas Survey staff about map production and distribution, software and hardware requirements, pricing of products, and other aspects of their operation.

Computer Systems

Design of Natural Resources Building Ethernet, *Wilson* A network has been designed to link all computing resources in the Survey using an Ethernet backbone and the telecommunication's B-jacks, which occur in every office. When implemented, the network will allow file transfer between computers, remote log-in to computers throughout the Survey, shared use of special peripheral devices, and access to campus computing resources via the University of Illinois' Proteon optical-fiber network.

Geoquest VAX Workstation, *Yeko, Lecouris* A VAX 3200 workstation with ZYCOR mapping, Geoquest well log and Oracle database software was acquired with contract funds and installed in the Oil and Gas Section. This workstation expands the Survey's ARC/INFO software capabilities by providing means for geologists to create color-filled contour maps, cross sections, fence diagrams, interactive log shifting, synthetic seismograph capability, and rapid database retrieval.

Acquisition and Installation of the SUN 3/60 Workstation, *Wilson, McKay* A SUN 3/60 workstation with ARC/INFO and Oracle was acquired with contract funding and installed in the Computer Research and Services Section for the use of Survey staff. The workstation will expand the availability of computing power on the Geographic Information System (GIS), which recently has been seriously taxed.

Database Computer System Design, *McKay, Wilson, Denhart, Treworgy, Riley, Yeko* A subcommittee of the Computer Committee investigated the hardware, software, and communications requirements to upgrade the Survey's management of automated databases. The committee recommended a system built around the Oracle relational database software, connected to all existing minicomputers and workstations via Ethernet, and run on a server computer capable of serving 40 database users simultaneously.

Technology Transfer and Information Services

National GIS Symposium, *Graettinger, Hindman, Krumm, McKay, Pool, L. Smith, Taylor, C. Treworgy* In September 1988, Survey staff members participated in a national GIS meeting held in Denver, Colorado. The symposium, "Integrating Technology and Geoscience Applications," was sponsored by the National Academy of Sciences, the U.S. Geological Survey, and the Association of American State Geologists. Survey programs received substantial exposure as staff contributed six oral presentations and one poster session during the week-long symposium.

In May 1989, Survey staff attended the ESRI ARC/INFO Users Conference in Palm Springs, California. This meeting is one of the premier GIS conferences and provides a forum for information exchange among users, paper presentations, hardware and software demonstrations, poster displays, and technical training sessions. The Survey poster, "Geologic Applications of ARC/INFO: Examples from Illinois" won first place for the "Most Analytical Poster" of the conference.

Custom Map Production for Southwestern Illinois Brick Manufacturing Feasibility Study, *Krumm, Taylor* At the request of the Southwestern Illinois Metropolitan and Regional Planning Commission (SWIMPC), a series of five maps was produced to help assess the feasibility of establishing a brick manufacturing facility in that part of the state. In the past, the brick industry has been a thriving business in the Metro-East area. SWIMPC sponsored this feasibility study to (1) determine the economic and mineral resource factors needed to revive this industry, and (2) identify several potential brick manufacturing sites in the seven-county area. The Geographic Information System was used to produce maps showing the thickness of glacial drift, all streams and rivers, and the extent of Pennsylvanian rocks in the area. SWIMPC selected several candidate sites based partly on these maps and information supplied by the Survey's Clay Minerals Unit.

ILLIMAP Data, *McKay, Wilson* Public Land Survey data for Illinois are available from the Survey on computer tape. During the past year the Computer Section has supplied such data for parts of the state to eight individuals and agencies. Arrangements have been made to grant use of the datafile to the Illinois Department of Transportation.

SCIENTIFIC SUPPORT SERVICES

Quality Assurance/Quality Control

Quality Assurance/Quality Control Committee, *Dreher, Harvey, Chaven, C-L. Chou, J. Frost, Herzog, Roy, Griffin* The quality assurance/quality control committee wrote a general quality assurance plan for the Survey. The plan was presented to and approved by the Management Committee. Copies of the plan were distributed to Survey staff members, then a seminar was held to introduce the plan and discuss it. The first step in implementing the plan is for Survey staff to write "Standard Operating Procedures" for each routine procedure that either produces quantitative data or leads to its production.

Standard Operating Procedures for Coal Section Laboratories, *Harvey, Demir, Lowry* As part of the Quality Assurance/Quality Control (QA/QC) program, standard operating procedures were written for the two analyses performed in the coal petrography laboratory: maceral analysis and reflectance analysis. Procedures were written to (1) prepare samples (specimen pellets) for these two analyses, and (2) determine the organic-sulfur content within individual maceral particles utilizing a petrographic microscope and the SEM-EDX instruments. The last remaining procedures that require documentation are for low-temperature ashing to determine mineral matter in coal and the palynological content of coal samples.

Coal Analysis Laboratory, *Chaven, Henry, Hurley, Gavrilovic* More than 1,500 samples of coal and coal-related products involving more than 7,000 analyses were analyzed by the Coal Analysis Laboratory to support many ongoing projects. Two analytical instruments were added to the

laboratory this past year: (1) a Leeds and Northrup particle-size analyzer (Build Illinois funds), which uses state-of-the-art laser-scattering technology so that particle sizes ranging from 0.7 microns to 700 microns can be quantitatively analyzed through remote control, and (2) a coal-dedicated chlorine analyzer (LECO 350) in which total chlorine in coal can be analyzed in less than 5 minutes per sample--making it possible to provide faster turnaround for researchers in chlorine-removal projects.

Low-Temperature Ashing Laboratory Service, *Lowry* Thirty-one samples were processed in the laboratory as part of nine different projects reported elsewhere.

SEM-EDX Laboratory Service, *Lowry, Harvey, Demir, Seyler* The Scanning Electron Microscope Laboratory (Build Illinois funds) was used on 321 occasions (approximately 570 hours) during this report period by Survey operators working on projects reported elsewhere. Two additional staff received training from Lowry (principal operator) in the use of the SEM during the year. This laboratory, supported jointly with the Illinois Natural History Survey, was also used on 132 occasions by twelve of their staff.

Analytical Chemistry Services

Neutron Activation Analysis Laboratory, *J. Frost* The computer programs that are used to take gamma-ray spectrometer data from magnetic tape and translate them into concentrations of elements in geologic samples were previously run on the CYBER 175 computer, which was phased out. The programs were revised and converted to VS FORTRAN for operation on the IBM 3081 computer.

Characterization of International Rock Standards by Instrumental Neutron Activation Analysis, *J. Frost* The Analytical Chemistry Section in the spring of 1988 had cooperated with M. Voutchkov of the Bulgarian Institute of Sciences, Sofia, in a project sponsored by the International Atomic Energy Agency for the development of computer methods in energy-dispersive X-ray fluorescence analysis. Ten rock and ore standards of the European Community for Economic Development were analyzed in FY89 by instrumental neutron activation analysis. These standards, as well as NBS plastic clay 98, the Belgian fired clay FCG, and the Canadian sulfide ore-1 and syenite rock-1, were analyzed for more than 25 elements to compare results on five elements analyzed by the energy-dispersive X-ray method and to add more results to the data base in the literature.

Isotopic Geochemistry Services

Isotopic Analysis Service Laboratory, *Liu, Fisher, Riley, Hackley, Coleman* As a result of equipment made available by the Build Illinois Program, the Survey is now able to make stable isotope analyses available to the scientific community on a service basis. Facilities are available for isotope analyses of carbon, oxygen, nitrogen and sulfur on a variety of geologic and archaeologic materials. Stable isotope analysis has become a standard tool in many types of geochemical investigations.

During the report period carbon and oxygen isotope ratio analyses were completed on 1,373 samples. Approximately 10 percent of these samples were for QA/QC and standardization with the remainder distributed as follows: 65 percent for anthropological research projects at the University of Illinois and the University of Chicago, 10 percent in support of the Radiocarbon Dating Laboratory, and 15 percent in support of various Survey research projects (natural gas identification and limestone composition). New laboratory systems to allow hydrogen and oxygen isotopic analysis of groundwater are now near completion.

Radiocarbon Dating Laboratory, *Liu, McMillion, Coleman* The Survey operates the only Radiocarbon Dating Laboratory in the state (and one of only two in the midwest), thus providing radiocarbon (C-14) age determinations as a service to the geological and archaeological communities. During the report period, 169 radiocarbon age determinations were performed on geological and archaeological samples for scientists throughout the state of Illinois. Approximately

60 percent of these samples were funded by research projects. The remaining samples were submitted by ISGS Quaternary geologists and graduate students working on their dissertations. The laboratory provided 45 radiocarbon dates for U.S. Geological Survey and Illinois Geological Survey researchers investigating Illinois glacial deposits and Lake Michigan shoreline erosion.

Procedures for radiocarbon dating of groundwater are currently under development. Information obtained from radiocarbon dating of groundwater will help Survey hydrologists in characterization of major groundwater aquifers.

Inter-Survey Geotechnical Laboratory

The Inter-Survey Geotechnical Laboratory processed the following samples during the report period of July 1989 to June 1989:

Suspended sediment concentration	3125
Full particle-size analysis	235
Sand fine split/dry sieve	259
Sand/silt/clay breaks	268
Moisture/unit weights	29

Several studies from the Illinois State Geological and Water Surveys submitted samples to the laboratory for analysis, including the low-level radioactive waste, wetlands, clay liner, navigation impacts, Cache River, Lake Calumet, Peoria Lake, and benchmark monitoring network projects.

Computer Services

Microcomputer System Design, Setup, and Troubleshooting, *Witzany, Wilson, Graettinger, Ploetz, Pool, Yeko, Lecouris* The Computer Section assisted in the acquisition and installation of nearly 35 microcomputers during the last fiscal year. The Well Database Unit acquired two personal computers and assisted in the design, acquisition, and setup of an additional eight systems; the Unit also consulted on more than 15 troubleshooting calls. Consulting assistance to users of personal computers is expanding.

ZYCOR Training, *Yeko* A three-day class on how to use the ZYCOR software for mapping and cross-section creation was presented by staff. Seven people were trained in this hands-on class. An additional class is planned for late fall of 1989.

VMS Training, *Lecouris* A half-day class on how to use the new VAX workstation was designed and presented twice to a total of 14 Survey personnel.

Oracle National Users Group, *Yeko* The national Oracle convention was attended and information gathered was presented to interested staff at the Survey. Oracle system management techniques, including prototyping, were learned from convention presentations and are being used in the development of the CONQuEST system.

GIS Support for Publications, *Pool, Krumm, Taylor, McKay* The Computer Research and Services Section has been working with Publications, Graphics, and Photography Unit to facilitate their use of the GIS. CRSS has provided training and custom programing of ARC/INFO to fit their needs. Programs have been written to allow GIS-produced maps to be inserted into publications in the Ventura Publisher desktop publishing software. ARC version 5.0 has also provided a means for ARC/INFO to exchange data with the AUTOCAD program. The CRSS will continue to work closely with Publications to create databases and programs that support their activities and promote integrated data processing from data entry to publication.

Interface of Well Data Entry System on Personal Computers with Prime Computer, *Lecouris, Denhart, Yeko* The Geological Records Unit (GRU) is entering oil and gas well permit data on a personal computer system. Programs and procedures for transferring these data to the Prime 9955 and to the main well data files were written and released to GRU. This interface provides access for users of the main well data files to the most current permit data.

Sample Services

Tested Samples Database for Survey Laboratories, *Harvey, Wilson, Dreher, staff* As part of the work for the Ad Hoc Committee on Sample Data Management, an initial design of a database of Tested Samples using the file structure of ORACLE software was set up. Each laboratory that generates test results on samples has provided a name and abbreviation for each test they conduct. These will be important items for retrieval of sample descriptions from the database. In addition, a revised form for the General Request Form was prepared and tested. The revision is designed to make it easier for those requesting analyses to complete the form and thereby provide the required sample descriptors for the Tested Samples Database. Instructions were written to accompany the form.

DATABASE ENHANCEMENT

Groundwater database activities, *E. Smith, Seaber, staff* Survey staff organized and developed an automated groundwater database, utilizing water well records and other subsurface information on file at the Survey. The purpose of this project is to develop a database of subsurface information that will be more easily accessible to Geological and Water Survey staff and others who require this information via a computer network. The Geological Records Unit is entering water well records into the database. The format of the database was authorized and developed by staff of the Groundwater Section and the Groundwater Database Coordinator.

Survey staff have worked in committee with staff of both the Illinois State Geological and Water Surveys to coordinate the development of the groundwater database into a compatible system for all potential users. This includes a comparison and reconciliation of existing water well information available at other divisions of the Illinois Department of Energy and Natural Resources and the U.S. Geological Survey, oversight of the information being entered into the system, and guidance for the acquisition of new and existing subsurface information not presently available.

Catalog of Cores from the Sub-Galena Group in Illinois, *Shaw (Queens College), Sargent* Lower Paleozoic rocks in the Illinois Basin are currently the focus of much interest as potential reservoirs for hydrocarbons and sites for waste disposal, natural gas storage, and compressed-air energy storage. Interest in these possibilities was the impetus for compiling this catalog, which provides a reference to the cores on file at the Illinois State Geological Survey (ISGS) of sub-Galena Group strata. Five maps show the location of cores according to the stratigraphic interval that they represent. A stratigraphic summary of the cored interval is presented for each well.

Technical and Administrative Services



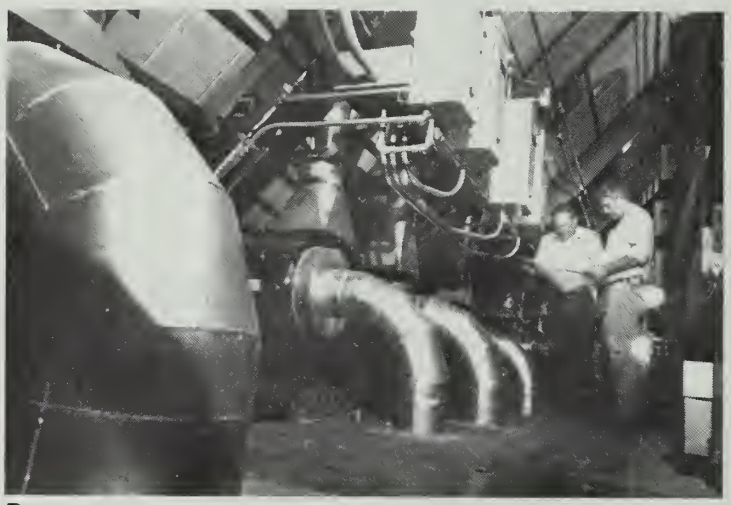
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(A) Ellen Wolf (second from right), coordinator of the Publications, Graphics, and Photography Unit, and artists Pam Foster and Mike Knapp (right) confer with Nick Schneider (second from left), acting head of Environmental Studies, and geologist Brandon Curry on the layout of a groundwater resources report. (B) Editor Mary Glockner checks illustrations for a manuscript to be published by the Survey. (C) Harris McKinney, technician in the Geological Samples Library, pulls out a drawer holding samples of insoluble residues. (D) Attic scene: as part of the laboratory upgrade, motors and fans were installed in the attic and roof to provide negative pressure in the exhaust stacks.

TECHNICAL AND ADMINISTRATIVE SERVICES

Vital operating functions support the Survey's research and service programs: budgeting, accounting, and financial reporting; contract and grant preparation and monitoring; timekeeping, counseling, and advising human resources; cataloging, searching, and locating library references; receiving and distributing incoming mail, commodities, and equipment as well as processing orders and shipping publications, maps, and other materials; maintaining the information office and the Illinois affiliate office of the National Earth Science Information Center; conducting public field trips, dealing with a variety of inquiries, and distributing educational materials; overseeing media and legislative relations; fabricating, maintaining, and repairing scientific, office, automotive, and other equipment and instruments; supervising the word-processing system and arranging changes in telephone programming and billing; providing editorial, graphic, typographic, duplicating, and other publications services; and planning and supervising new construction and building renovations.

The Geological Records Unit and the Geological Samples Library also provide vital technical services to the Survey's ongoing research and service efforts and to the public and private sectors. The documentation of Illinois geology maintained by these two units and the Reference and Map Library is the heart and soul of the Survey's activities and a basic source of information for private industry, government agencies, and the general public.

WORD-PROCESSING CENTER

Staff of the Word Processing Center provided secretarial services for the Technical and Administrative Services Branch, recordkeeping for the Contracts and Grants Office, document transfers between the NBI and WordPerfect, troubleshooting on the NBI, and telephone system changes and billing for the Survey. They handled requests for maintenance performed by the University of Illinois Physical Plant, vehicle reservations, mail distribution, and loan copies of out-of-print ISGS publications. They served as an interface between the Survey's Administrative Branch and various departments of the University of Illinois. They provided assistance in the Information Office, Mail Room, Business Office, Human Resources and the Chief's Office when their respective staff members were on leave. Currently, personnel from this unit are revising the List of Publications.

Juggling the Survey's fleet of vehicles to accommodate the field work and travel needs of the scientists is a concern of this unit. With the initiation of a system to charge specific grants and contracts their associated vehicle mileage expenses, the staff helped develop new reservation forms along with a procedure for the transfer of funds to cover such mileage.

Responsibilities for telecommunications also rest with this unit. In addition to routine reporting of troubles with telephones, the unit handled required changes in the telecommunications and billing for each personnel move within the Survey. Telephone service orders were generated for each transfer of jacks between rooms or buildings; each jack's location and whether it was active or inactive was recorded. As personnel were added to or moved from one contract and grant to another, corresponding phone billings were also shifted to the new contract and grant to reflect these changes.

For the Contracts and Grants Office, records were kept of University of Illinois employees, contracts and grants, and proposals on WordPerfect and the NBI.

Draft copies of press releases, reports, contributions to outside journals and newsletters, fact sheets, correspondence, updates to the Calendar of Events and special meeting literature prepared by the Public Liaison Officer were finalized for printing or release by the Word-Processing Center. During peak production periods this past year, both staff members assisted with this work. One person has been allocated about one-fifth time to the public liaison effort.

On the basis of a 3.5-month sampling, the mail distribution projected for the reporting period included 79,712 pieces of mail and 5,308 items received for the Library. These figures indicate a decrease in mail handling of more than 12,300 single pieces, while Library receipts dropped approximately 1,140 items since FY 1988.

Whatever the problem--burned-out light bulb, broken door lock or adjuster, malfunctioning elevator or radiator--the unit prepared maintenance requests to obtain service from the University of Illinois Physical Plant. In addition, this staff updated the telephone list and hall staff directories.

BUSINESS AND FINANCIAL SERVICES

During the past year, the Business and Financial Services Unit implemented a comprehensive internal contract and grant accounting system, which has received wide support and acceptance. This effort required the connection of two additional work stations and a double-sided laser printer to handle the work load. The staff will continue to enhance the system and improve its flexibility in the coming year.

Implementation of the new contract and grant accounting system required the addition of one new staff member, reassignment of an existing staff member, and reorganization of the existing duties and responsibilities of the remaining personnel. During the last reporting period, another staff member retired. These changes required that three new staff be recruited and trained. All three are now functioning in their new positions. Changes in the physical layout of the unit and reassignment of responsibilities among the staff have resulted in improved productivity and better utilization of existing skills and abilities.

In this reporting period, the staff increased and improved internal data reporting and analysis to the Branches, streamlined purchasing for research projects through the utilization of departmental purchase orders and continuous purchase orders, and initiated electronic transfer of the Survey's payroll warrants directly from the Comptroller's Office. This unit was instrumental in the introduction of a legislative amendment that would permit state-paid employees payroll deduction privileges for parking fees at the University of Illinois. This legislation, to become effective January 1, 1990, will ease some of the financial strain on staff of escalating campus parking fees.

The Business and Financial Unit was recognized by the Illinois Department of Energy and Natural Resources for its excellent job in preparing the FY 1990 House and Senate budget forms and submitting them in a timely manner. In addition, the unit compiled and tabulated the financial data for the operating support line initiative, part of a Senate amendment that proved unsuccessful. It also helped to formulate and gain ultimate approval of a general services concept that provides for appropriate administrative and technical staff members to be proportionally funded by the sponsored research projects they serve.

Throughout the year, the unit continued to fulfill its fundamental responsibilities of purchasing, vouchering, and accounting for all state appropriated and allocated funds of the Geological Survey. The unit was instrumental in securing a timely purchasing agreement between the Purchasing Division of the Department of Central Management Services (CMS) and a vendor, eliminating an additional 18-percent increase in the price of a rock core saw, installed at the Natural Resources Annex. Through CMS, the staff also secured third-party financing for a new Multigraphics duplicator to be financed over four fiscal years.

GRANTS AND CONTRACTS

During this reporting period, the Grants and Contracts Office was transferred from the Chief's Office to the Technical and Administrative Services Branch. The Grants and Contracts Officer acquired an assistant to handle administrative functions and provide computer support services to the Branch. The staff is involved in identifying new sponsorship opportunities as well as all phases of proposal development, including internal procedures, submission, approval, agreement

development, contract terms and conditions, and some phases of administration--all under the guidelines of the University of Illinois and the Board of Natural Resources and Conservation. After implementation of an agreement, the accounting function is transferred to the Business and Financial Services Unit. Besides microcomputer support, the staff also provides equipment justification, system implementation, and troubleshooting of basic computer problems for several units of the Branch.

A new system for recovery of reasonable and allocable direct expenditures associated with general services rendered in support of sponsored activities at the Survey was implemented during FY 1989. This system addresses the previous lack of either direct or indirect support for additional services demanded by the large proportion of state-funded contracts and grants at the Survey.

HUMAN RESOURCE OFFICE

Activities of the Human Resource Office during the reporting period reflected a 55-percent increase in the personnel searches conducted (51 versus 33 in FY 1988) and generated 1,028 applications, a 7-percent decrease from the previous year. Only three major searches were conducted--for the General and Environmental Geology Branch Head, a petroleum engineer, and a scientific photographer. An average of 21 applications were submitted for each search, and two or three candidates were interviewed for each vacancy, amounting to 101 candidates receiving interviews, seven less than in FY 1988.

Of the 51 searches made during FY 1989, 36 were efforts conducted on behalf of grants and contracts and 15 were for state-funded vacancies, of which 10 were for temporary posts funded by the Lands Unsuitable for Mining Program (LUMP). These temporary positions required the same efforts as those made for posts funded by the state or grants and contracts: advertising, accepting applications, reviewing credentials, interviewing candidates, sending acceptance and regret letters, and processing papers regarding the newly hired personnel. During the previous reporting period, 29 of the 33 searches were made on behalf of grants and contracts and four for state-funded positions.

Other personnel activities performed by the staff of two included the processing of 15 new state appointments, nine resignations or terminations of state personnel, one retirement, 22 exit interviews, 48 new contract personnel, 96 transfers of contract personnel, 63 extensions of contract personnel, 43 separations of contract personnel, 2,916 acknowledgment letters, six requests for approval to hire or transfer, five requests for exception to hiring freeze, and 12 requests for temporary appointments. The office also processed benefits for 42 new employees, four termination reports for the State University Retirement System (SURS), 81 status of participation reports to the SURS, 22 applications and changes for deferred compensation, 261 staff inquiries on benefits, 85 data changes on tax cards, and 116 data changes on all insurance.

Administering and processing benefits, formerly handled by the Business and Financial Services Unit, has been the responsibility of the Human Resource Office for the entire year. Major changes were made by Central Management Services in health, life, and dental insurance, and many options were made available to state employees. Two informational seminars were conducted to explain each health insurance plan as well as the changes in dental insurance and life insurance. More than 90 Survey staff members attended these sessions.

The Human Resource Office placed additional emphasis on staff training, conducting five seminars to provide information to supervisors and staff on the Survey's Performance Assessment and Development Planning System. Two seminars were conducted for supervisors and three for the staff. These seminars, which provided an opportunity for discussion and clarification of the ISGS appraisal system, were attended by 175 staff members.

When the Survey reorganized in December 1988, staff members were transferred to new sections, new sections were created, sections were split, and one group was dissolved. These changes necessitated rewriting job descriptions, a project still in progress. In addition, the former supervisors were asked to informally evaluate those moving to new sections and supervisors. These appraisals were incorporated into formal appraisals in spring 1989. The Human Resource Office coordinated these efforts.

Normal daily activities required supplying information for 783 inquires from the staff or public, and responding to 5,220 phone calls (more than three times the number received in FY 1988) with an additional 2,610 phone calls placed, up from 1,000 the preceding year. Staff attendance records were audited 18 times and 354 identification cards were processed. For the Department of Energy and Natural Resources, the office prepared the director's monthly report and a work force analysis, work force analyses required by Central Management Services and Illinois Department of Human Rights, and other reports on absenteeism, new hires, Women in Science, degrees and salaries of staff, and a child care survey. Reports generated for the Survey covered on/off personnel status, OSHA, studies of engineers, turnover, training and development, salary history and performance, proposed salaries, study of secretarial support, review and justification of staff's performance appraisal, internship program, and accidents.

LIBRARY/MAP ROOM AND PUBLIC INFORMATION

Major reorganization took place September 1, 1988, as the Library/Map Room Unit joined the Public Information Unit under the supervision of the Librarian, and the Public Liaison function became a separate entity. The current expanded unit comprises the Library, Map Room, Earth Science Information Center, Information Office, Mail Room, and Duplicating Shop. Because most of these are one- or two-person offices, a program of cross-training was started to provide back-up personnel to cover leave time. Although not yet complete, this program has been moderately successful, allowing the unit to cover most staff shortages. The position of a staff member who resigned June 30 has since been filled. Assistance from staff of the Technical and Administrative Services Branch Office is occasionally necessary.

Library/Map Room

The Library/Map Room provides reference services to Survey staff. Routing of journals, bibliographies, lists of acquisitions, and other materials alerts staff to developments in research. The librarians complete and verify citations, prepare bibliographies, run online literature searches, locate and borrow articles and books from other libraries, and explain the use of campus libraries as well as the Survey Library to staff.

The Library's staff was effectively but not actually cut by one librarian this past year because of increased management responsibilities and work on the Superconducting Super Collider (SSC) Archives. The unit anticipates an increase of effective staff with the completion of the SSC project.

The SSC Archives project has been completed, and a final archival listing is nearly complete. The archives contain 150 cubic feet of materials, including files from the "SSC for Fermilab" (Fermi National Accelerator Laboratory) office, maps and audiovisual materials, newsletters, and newspaper clippings. A set of 107 oversize aerial photographs from the SSC project was identified and also cataloged.

All publications of the Illinois State Geological Survey have been entered into the Library's online database. In addition, the Survey's portion of the Lincoln Trail Union List of Serials was updated. This list is used by libraries within the state to locate items needed through interlibrary loan.

Because of seriously limited space, the Library remains in an overall no-growth position, and acquisitions have decreased. Journal routing has increased. The flexibility of the current journal routing system has been an important factor in handling this increase. Library circulation has

decreased, possibly because of a change in the way circulation is counted. Items taken only for photocopying are no longer included in circulation figures.

In the Map Room, the long-lost "Atherton" cross sections and other miscellaneous cross sections were found and cataloged to help Survey researchers take advantage of previous work. Index lines for the cross sections were prepared to make the sections easier to use.

Library Operating Statistics

Acquisitions	**1986-87**	***1987-88**	**1988-89**
Total	*4084*	*3857*	*2045*
Books	67	120	80
State documents	399	416	496
U.S. documents	576	665	573
Canadian documents	176	106	64
Miscellaneous documents	287	234	227
Manuscripts	32	98	50
Maps	2445	490	547
Photos, slides, other	102	2161	8
Total items withdrawn	465	564	108
Serials titles and newsletters received	326	307	313
Library circulation			
Total	*3350*	*3238*	*3185*
Books, documents, serials	2756	2181	1929
Maps	502	842	991
Field notebooks, photos, slides, other	92	181	87
Interlibrary loans (lent)	---	34	178
Journal routing			
Periodicals routed	1071	1627	1769
Tables of contents routed	---	320	462
Interlibrary loans (borrowed)			
Total	*679*	*746*	*778*
From University of Illinois libraries	462	476	200
Through Lincoln Trail Libraries System	217	270	318
Direct from other libraries	---	---	260
Reference questions	1427	1927	1504
Online bibliographic searches	26	22	42
Visitors	310	310	278
Outside phone requests	---	211	158

* adjusted to 12 months

Earth Science Information Center

Cooperative topographic mapping New or revised editions of 126 maps in the 7.5-minute, 1:24,000-scale quadrangle series were authorized in four separate projects. The projects covering the quad cities (Rock Island, Moline, Davenport, and Bettendorf), parts of southwestern and northeastern Illinois, and an area along the Illinois-Indiana state line are being funded by the U.S. Geological Survey (USGS) and the states of Illinois and Indiana. Basic horizontal and vertical control surveys have been completed for 30 of the maps.

Nine of the 46 maps in the 1:100,000-scale, 30' x 60' quadrangle series have been converted from the planimetric to topographic format. There are now 50 1:100,000-scale, planimetric county maps. Two additional county maps, Livingston and Madison, are in preparation.

Other affiliate activities The National Cartographic Information Center (NCIC) of the USGS is now called the Earth Science Information Center (ESIC). In March, the NCIC offices were combined with the USGS Public Information Offices (PIO) to form ESIC. Formerly devoted exclusively to cartographic information coordinated by the National Mapping Division-USGS, the newly formed ESICs will be able to provide information about products and services of the Water Resources and Geologic Divisions as well. Because the Illinois State Geological Survey has been a center for earth science information since 1905, the staff anticipates few difficulties in assuming whatever new responsibilities that attend the expanded role of the affiliate.

Information Office

The Information Office is the central office for handling general public inquiries. More detailed questions are referred to scientists. The staff handles over-the-counter sales and processes orders for Illinois Geological Survey maps and publications and USGS maps of Illinois. This office is also responsible for recording sales, developing mailing lists for publication announcements and selected publications, responding to claims, and in cooperation with the Publications Unit, determining print runs based on anticipated sales and gift and exchange distribution.

Customer service is a major concern of this unit and the Information Office. The adoption of Mastercard and VISA as a means of payment last year has been popular and successful. Another popular service is Federal Express collect shipping, which guarantees prompt delivery. A $3 service charge for Federal Express collect orders was instituted May 1 to help cover special handling costs. From a new display rack, customers are able to examine and select new publications.

A comparison of Information Office sales for fiscal years 1988 and 1989 showed revenue increased $2,800. Sales of blueline maps and two new services, computer-generated maps and lamination of maps, were largely responsible for this increase. Sales of Survey publications also increased, while sales of printed maps decreased.

Northeastern Illinois Office

Over-the-counter sale of topographic and planimetric maps of northeastern Illinois began in September, and a display of maps was presented in the lobby of the State of Illinois Center (SOIC) from November 29 to December 9, 1988.

Administration of the Northeastesrn Illinois Office, located at the SOIC in Chicago, was transferred from the Environmental Studies and Assessment Section to the Assistant Branch Chief of the Environmental Geology and Geochemistry Branch under the reorganization of the Survey in December. This change was made to reflect internally that the office represents more than just the one section of the Survey.

Mail Room

As the central receiving and distribution center for the Survey, the Mail Room handles shipments, orders and stocks office supplies, and initiates inventory control of equipment. In addition to processing bulk mailings, the staff fills and ships mail/phone orders of all in-print materials from the stock maintained for customers and staff. Projects completed during this fiscal year included reorganizing publication storage in the loft and relabeling and organizing the map storage areas.

In October, responsibility for well log copying was transferred from the Mail Room to the Geologic Records Unit. A work area for checking in and processing outgoing large map orders was created in the area formerly occupied by the copiers. This reorganization has improved efficiency since large order processing, which often requires several days, can now be completed without using the area needed for routine order processing.

Distribution of maps and publications in FY 1989 compared to FY 1988

	FY88	FY89
Illinois State Geological Survey		
Publications	27,990	24,654
Maps	7,755	2,640
Blueline maps	2,974	3,860
U.S. Geological Survey maps	23,573	21,713

Individual orders for FY89 totaled 5,214. Postage meter use totaled $21,467 for 61,843 pieces.

Duplicating Service Shop

During the year, the Duplicating Service Shop received two new major pieces of equipment, a duplicator and binder, which enable the staff to completely produce nearly all of the Survey's publications. In January, a Multigraphics 1862 GPC 2-head offset duplicator was delivered. Two of the staff received Advanced Printing Techniques training from Multigraphics operators. In May, a Bourg 361 perfect binder was installed to provide wraparound covers. Output of the shop has increased: impressions made this year were 2,254,061, up 4,605 from the previous reporting period. A student assistant was hired to help with operations related to duplicating.

With additional equipment, the shop was reorganized to make more effective use of its available space. Infrequently used equipment was moved to other rooms to increase both work and storage space. Additional equipment made and installed by the Technical Design Shop included two new wall cabinets to hold inks, a large light table, a custom light-tight cabinet for metal plate and negative storage, and an additional storage unit for map originals used in blueline production.

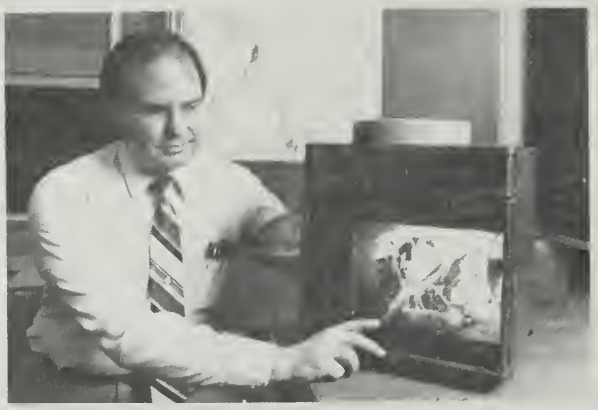
PUBLIC LIAISON

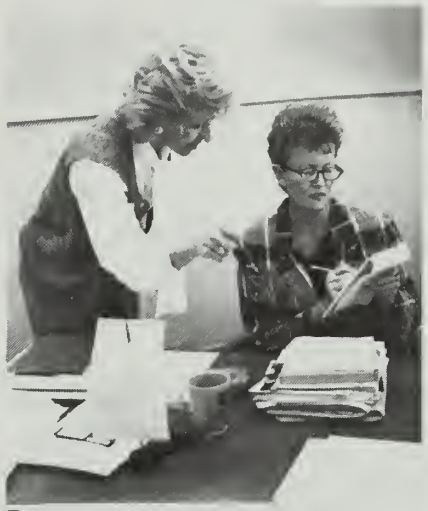
To provide more time for public relations, this function of the Public Relations and Information Unit was made an independent entity and renamed the Public Liaison Office of the Technical and Administrative Services Branch in the fall of 1988. Originally charged with informing the public and decision makers about Survey research and service programs and significant events, public relations two years ago took on added responsibilities for portions of governmental relations and selected strategic planning activities. During the last reporting period, a concerted effort was launched by this staff of one to apprise governmental officials at all levels--local, county, regional, state and federal--of the Survey's work.

The need for this form of information and technology transfer to governmental units has been reinforced by funding restraints on all sectors of government and the urgency to make prudent and safer use of the land available for resource and economic development. More regional planning, involving wise, environmentally sound decisions about siting new facilities or locating, developing and protecting natural resources, places the Survey, with its vast geological knowledge and expertise as well as its databases, in a position to assist in vital decision-making processes. To this end, the Public Liaison Officer is reaching out to city, county, and regional planners, engineers and zoning officials, as well as legislators, the legislative staff, the Governor's office and departments of state government to make them aware of and keep them informed about the Survey's research and service projects. A meeting was held for the legislative staff in January at the three Scientific Surveys. The Public Liaison planned and moderated the presentation made by the Illinois State Geological Survey and provided coordination among the Surveys.

In a new program instituted last year, during business travels, the Public Liaison is visiting grassroots officials and community leaders to familiarize them with the Survey. For the first time, Survey staff attended both fall and spring conclaves of county officials and provided brochures, fact sheets and an exhibit of maps at the Survey booth. A presentation on the Illinois Geographic Information System (IGIS) was also arranged for county board chairmen and zoning officials to introduce them to potential uses for the Survey's data.

A





B



C



D



E

(A) Jon Goodwin, assistant to the Chief, shows the slide/audio tape, "Groundwater—Protecting Our Invaluable Hidden Resource." (B) Suzanne Muckensturm, public liaison, and Eileen Conley, administrative aide in the Mineral Resources and Enineering Branch, check over information for a press release. (C) Artist Pam Foster checks the focus of the PMT camera. (D) Participants in one of the spring field trips scheduled by the Educational Extension Unit examine a roadcut at one of the stops. (E) Mary Krick (right), head of the library and public information, and librarian Kristi Mercer locate volumes for a geologist.

Promoting closer relations between the Illinois State Geological Survey and its constituency--the Illinois delegation in Washington, D.C., the Illinois General Assembly, the Department of Energy and Natural Resources (ENR), the Governor's subcabinets, the Society for the Illinois Scientific Surveys (SISS), news media, target groups and the public--the unit has provided a flow of in-depth information. News of research and service was disseminated through a new, public-oriented mini-annual report; press conferences and meetings for special-interest groups; articles for magazines, newsletters, and journals; personal letters; press releases; reports; brochures; speeches and exhibits. The Survey's first postcards, depicting the Bedrock Geology of Illinois and Quaternary Deposits of Illinois, were published and introduced at an international convention.

On a monthly basis, the latest information on major research efforts has been sent to ENR's Springfield office for incorporation into reports to the Governor's subcabinets on Economic Development and Natural Resources. In this way, department directors and the governor's staff are apprised of Survey research and its potential impact on the economic and environmental well-being of the state as well as its natural resources. The Public Liaison also prepared an extensive report for the Director of ENR on the future value of data generated by research to site the Superconducting Super Collider (SSC) in northeastern Illinois.

In addition, articles were prepared for the SISS magazine, *Nature of Illinois*; the American Association of State Geologists (AASG) newsletter; ENR's newsletter, *Illinois Resources*; the Illinois Coal Association's "Coal Facts" booklet, ENR's annual report and brochure, and the State's Bluebook. Besides teaming media with scientists working on specific issues, the unit arranged interviews for special video productions and news features taped by ENR for distribution to the electronic media throughout the state. The Public Liaison also administered a jointly held news conference with the U.S. Geological Survey, the Indiana Geological Survey and the Illinois State Geological Survey concerning their research efforts on Lake Michigan and coordinated poster sessions and the preparation of a media packet for this event. Working with ISGS scientists, the unit prepared press releases on personnel changes, awards, or special recognition; geological science field trips; drought damage to building foundations; cave formations; the SSC; future uses for the vast database generated by SSC research; the enhanced oil recovery program; a pilot project on rural wells; and mine subsidence publications. Announcements and press releases were generated to market new publications, while a brochure designed and prepared by the Publications Unit promoted a new series of mined-out area maps. To enhance distribution or marketing of Survey publications and information, the Public Liaison also created or updated selected mailing lists containing more than 3,000 addresses. In addition, the staff made personal media contacts in the south-central, east-central, central, western and northern parts of the state, delivering packets of information describing major projects.

Displays were erected and hosted at the Illinois State Fair, two statewide meetings of County Officials, University Day at the University of Illinois, the Illinois Science Teachers' annual meeting, the State of Illinois Building, and local and University of Illinois events. To modernize Survey displays, a 10-foot, velcro-receptive folding exhibit and shipping case were purchased through this unit's fund-raising efforts in the private sector.

PUBLICATIONS, GRAPHICS, AND PHOTOGRAPHY

Successful computer streamlining of the editorial operation in 1987-88 led to an expansion into computer graphics in 1988-89. The Computer Research and Service Section and Publications strengthened ties as the unit's first graphics system was linked to the Prime by midyear. Not only does this connection access pen plotters and assorted printers--it also accesses the Prime system directly. Scientists already have the option to input information for graphics on their personal computers, then bring the floppy disk to Publications for visual enhancement, editing, and final output. Now they can input data into the Illinois Geographic Information System, manipulate it, and transfer the files online to the graphic artists for design, color balance, text adjustment, and camera-ready output. The Survey mapping program will clearly benefit.

Another opportunity for better service to scientists arose in late 1988 when a new photographer joined the team. Demand for professional photo documentation in the field had dropped. But the outstanding results of one trip into the field with a geologist mapping southern Illinois was all it took to persuade scientists to call a professional in the future. Field photo expeditions—some high flying—averaged two per month.

Complex needs, custom products In 1988-89, output of final products dipped to 1985-86 levels (table 1). Scientific priorities also called for cutbacks in administrative projects. Yet the quantity of typeset text (table 2), which provides a rough measure of editing and drafting rounds, jumped from 1,950 pages in 1987-88 to 2,700 pages in 1988-89:

- Revision cycles due to authors' alterations increased as editors and artists kept pace with the scientists' drive for award-winning publications and posters.
- Scientists used their personal computers to turn out simple graphs—freeing artists for complex color projects, custom designs, and computer training and experimentation.
- Advance services—ahead of technical review—had mixed results. But the success in delivery of timely, cost-effective services for the Illinois Mine Subsidence Research Program and the groundwater protection program encouraged the unit to pursue this strategy—with some restraint.

Outreach For scientists and the Public Liaison, the unit prepared 22 posters, including the 44-foot display for the International Geological Congress held in Washington D.C. in July 1989. The display, "ISGS Maps the Future of Illinois," was presented by the head of Educational Extension, the Public Liaison, and the Chief. The unit's commitment to scientific information for the public held strong with a steady output of reports, educational booklets, fliers, and the *ISGS Geonews*.

Resource capacity In 1988-89, Publications expanded from three to four computer stations for editors. Computer graphics became a reality, and eight types of software enhanced the system's flexibility. The Publication's team remained compact: one fulltime and two halftime editors, three fulltime artists, a typographer, and the coordinator. Two student draftsmen assisted with contract work. After a five-month interval following the retirement of the unit's scientific photographer, the position was filled on December 16, 1988.

Table 1. Final Projects*

	1985-86	*1986-87*	*1987-88*	*1988-89*
Circulars	2	4	3	2
Environmental Geology series	3	6	9	3
Illinois Mineral series	2	2	3	2
Illinois Petroleum series	1	0	3	2
Illinois Mine Subsidence Research (limited series)	-	-	5	1
Educational Extension Field Trip Guides	4	2	6	4
Reprints of outside publications	14	16	22	18
Contract/Grant Reports	5	3	1	2
Cooperative Groundwater Reports	1	0	0	2
Illinois Scientific Survey Joint Reports	0	0	0	0
Papers, articles, published speeches	25	24	36	22
Plates (>8 1/2 by 11 inch)	3	3	3	3
Promos: brochures, fliers, announcements	4	13	19	15
Posters: scientific presentations	15	30	29	20
Posters and displays: public relations**	-	-	17	4
Special & administrative, including SSC	36	16	20	9
Geonews	-	3	3	3

* abstracts, only 4 to 11 per year--and only 2 hours editing each, have been removed from the list.
** including 44-foot display for International Geological Congress.

Table 2. Graphics*

	1986-87	1987-88	1988-89
Miscellaneous maps, cross sections, diagrams	1,030	1,321	951
Graphics for ISGS publications, including SSC	458	439	500
Totals	*1,488*	*2,314*	*1,451*
***Typographics** (number of pages)*			
Text, slides, tables, forms, charts, ads	2,157	1,950	2,700
Photographics			
Photos taken for staff	1,134	1,387	6,336
2 x 2 inch slides: color	4,247	5,562	2,600
duplicates	2,514	3,105	3,200
Internegatives	-	-	300
Negatives, total	-	-	179
fineline	-	-	65
high-contrast	-	-	85
screened	-	-	29
PMT prints developed for staff, total	5,721	6,038	4,835
screened	522	583	270
reversal and acetate	-	-	165
line (not split out before)	-	-	4,400
Prints made, total	4,102	5,469	5,450

* artists design and paste up more publications. Editors used to perform this task.

ISGS publications for July 1, 1988 through June 30, 1989 include the following:

Circular series comprehensive reports and reference works representing completion of a major phase of geologic research, a critical development in stratigraphy, or other substantive and enduring compilation of data.

C 535 *Glaciation and Origin of the Geest in the Driftless Area of Northwestern Illinois.* 1989. H. B. Willman, H. D. Glass, and J. C. Frye. 44 pages, 3 tables, 14 figures.

C 541 *A Study of Trench Covers to Minimize Infiltration at Waste Disposal Sites.* 1988. K. Cartwright, T. H. Larson, B. L. Herzog, T. M. Johnson, K. A. Albrecht, D. L. Moffett, D. A. Keefer, C. J. Stohr. 92 pages, 89 figures.

Environmental Geology series timely reports of significant advances or pivotal discoveries in basic and applied environmental geological research.

EGN 125 Revised edition: *Disposal Alternatives for Material to be Excavated from the Proposed Site of the Superconducting Super Collider in Illinois.* 1988. 17 pages, 5 figures, 5 tables.

EGN 129 *Evaluation of Groundwater Monitoring Programs at Hazardous Waste Disposal Facilities in Illinois.* 1988. B. L. Herzog, B. R. Hensel, E. Mehnert, J. R. Miller, and T. M. Johnson. 86 pages, 18 tables, 51 figures.

EGN 130 *Geochemical Interactions of Hazardous Wastes with Geological Formations in Deep-Well Systems.* 1989. W. R. Roy, S. C. Mravik, I. G. Krapac, D. R. Dickerson, and R. A. Griffin. 52 pages, 16 tables, 25 figures.

Illinois Minerals series reports of significant advances in basic and applied research in the area of mineral resources, or compilations of mineral economic data.

IMN 99 *Illinois Mineral Industry in 1987 and Review of Preliminary Mineral Production Data for 1988.* 1988. I. E. Samson. 45 pages, 25 tables, 12 figures.

IMN 100 *Illinois Mineral Industry in 1986 and Review of Preliminary Mineral Production Data for 1987.* 1989. I. E. Samson. 40 pages, 25 tables, 11 figures.

Illinois Petroleum series reports of significant advances in basic or applied research in the area of oil and gas resources or compilations of essential data on fuels exploration and research.

IP 131 *Oil and Gas Developments in Illinois, 1986.* 1989. B. G. Huff. 76 pages, 9 tables, 2 figures.

IP 132 *Catalog of Cores from the Sub-Galena Group in Illinois.* 1989. T. H. Shaw and M. L. Sargent. 30 pages, 6 figures, 2 photos.

Illinois Mine Subsidence Research Program series

Industry briefing: cover for notebook, other materials

Cooperative Groundwater Report series

Coop 11 *Agricultural Chemicals in Rural, Private Water Wells in Illinois: Recommendations for a Statewide Survey.* 1989. D. P. McKenna, S. C. Schock, E. Mehnert, and S. C. Mravik. 109 pages, 15 tables, 17 figures.

Coop 11 *Executive Summary: Agricultural Chemicals in Rural, Private Water Wells in Illinois: Recommendations for a Statewide Survey.* 1989. D. P. McKenna, S. C. Schock, E. Mehnert, and S. C. Mravik. 10 pages, 3 figures.

Contract/Grant Report series

C/G 1988-1 *Ultrafine Coal Cleaning Via Explosive Shattering and Aggregate Flotation Processes.* 1988. R. R. Ruch, G. C. Sresty, R. B. Read, P. J. DeMaris, D. M. Rapp, C. W. Kruse, C. Chaven, and M. S. Summers. 38 pages, 21 tables, 9 figures.

C/G 1989-1 *Shallow Groundwater Resources Assessment for the Village of Montgomery, Illinois.* 1989. S. S. McFadden, C. R. Gendron, and F. A. Stanke. 17 pages, 2 tables, 10 figures.

Educational Extension Geological Field Trip booklets

1988-C *Forrest Area, Livingston County.* October 1988. D. L. Reinertsen, L. R. Follmer, J. M. Masters, and P. C. Reed.

1988-D *Wolf Lake Area, Union and Jackson Counties.* November 1988. D. L. Reinertsen and P. C. Reed.

1989-A *Newton Area, Jasper County.* April 1989. C. P. Weibel, D. L. Reinertsen, and P. C. Reed.

1989-B *Savanna Area, Carroll and Jo Daviess Counties.* May 1989. D. D. Reinertsen.

Reprints of papers published in journals or proceedings

1988 reprints 1988D, *Reevaluation of the Timing and Causes of High Lake Phases in the Lake Michigan Basin*, A. K. Hansel and D. M. Mickelson • 1988E, *Cyclothems in the Carbondale Formation (Pennsylvanian: Desmoinesian Series) of La Salle County, Illinois*, C. B. Trask • 1988F, *Fluvial-Deltaic Deposits (Caseyville and Abbott Formations) of Early Pennsylvanian Age Exposed Along the Pounds Escarpment, Southern Illinois*, R. J. Jacobson • 1988G, *Horseshoe Quarry, Shawneetown Fault Zone, Illinois*, W. J. Nelson • 1988H, *Size and Maceral Association of Pyrite in Illinois Coals and Their Float-Sink Fractions*, R. D. Harvey and P. J. DeMaris • 1988I, *Illinois: Description of Coal Seams*, H. H. Damberger • 1988J, *Origin of Clay Minerals in Pennsylvanian Strata of the Illinois*

Basin, R. E. Hughes, P. J. DeMaris, W. A. White, and D. K. Cowin • 1988K, *Organic Geochemistry of Ten Samples of Anna and Energy Shale Members of the Carbondale Formation (Pennsylvanian), Illinois Basin*, M. M. Chou, C.-L. Chou, and R. A. Allen • 1988L, *Ramp-Platform Model for Silurian Pinnacle Reef Distribution in the Illinois Basin*, S. T. Whitaker • 1988M, *Coal Deposits of the United States*, W. J. Nelson • 1988N, *Flash Pyrolysis of Coal, Coal Maceral, and Coal-Derived Pyrite with On-Line Characterization of Volatile Sulfur Compounds*, M. M. Chou, M. A. Lake, and R. A. Griffin • 1988O, *Changes in Volatile Organic Chemical Concentrations After Purging Slowly Recovering Wells*, B. L. Herzog, S.-F. J. Chou, J. R. Valkenbury, and R. A. Griffin • 1988P, *Engineering Geology Investigations of a Hazardous-Waste Landfill in West Central Illinois, USA*, C. Stohr, W.-J. Su, L. Follmer, P. DuMontelle, and R. A. Griffin • 1988Q, *Mapping Soil Thermal Properties in Illinois, USA*, T. H. Larson • 1988R, *Infiltration Through Layered-Soil Trench Covers: Response to an Extended Period of Rainfall*, T. H. Larson, D. A. Keefer, K. A. Albrecht, and K. Cartwright

1989 reprints — 1989A, *Illinois Basin Coal Sample Program: Status and Sample Characterization*, R. D. Harvey and C. W. Kruse • 1989B, *Infiltration and Hydraulic Conductivity of a Compacted Earthen Liner*, K. A. Albrecht and K. Cartwright • 1989C, *Development of Pedological Thought: Some People Involved*, J. P. Tandrich, R. C. Darmody, and L. R. Follmer

Special

Geonews — *Summer 1988, Winter 1989, Spring 1989*

Annuals — Two reports •*Illinois State Geological Survey Annual Report, May 1987 -June 1988.* 170 pages. •*ISGS 1987-88 Highlights of the Past and Present, and a Look at the Future.* 20 pages.

Directories — Coal Mine Directories and two catalogs for the Geological Samples Library

Exhibits — for R.D. Harvey, D.R. Kolata (3), M. Chrzastowski (2), A.K. Hansel, C.W. Kruse, M. Chou, J.Treworgy (2), S. Muckensturm (2), M. Rostam-Abadi, P. Reed, W.J. Nelson and R.A. Bauer (2), B.B. Curry, M. W. Leighton, G.E. Glogowski, J.P. Kempton and R.C. Berg

TECHNICAL DESIGN, OPERATIONS, AND MAINTENANCE

The Technical Design, Operations, and Maintenance Shop provides the Survey with special services that would otherwise have to be handled through contractual services of the University of Illinois or outside vendors. Survey shop personnel install and maintain the air conditioners; repair, install, maintain and move office/laboratory furniture and fixtures; unclog and repair drains; and otherwise care for many parts of the Survey laboratories and offices that are considered departmental responsibilities. The staff also provides upkeep and maintenance to the Shop and Equipment Building and the Clay Hydrogeology Liner Building, which required correction of drainage from roof gutters. The water problem was resolved by adding extra downspouts, a plastic liner, and drainage tubes.

Custom fabrication and repair of laboratory, field, and scientific apparatus as well as office equipment and furniture are specialities of the technical design staff. Noteworthy projects of the 1988-89 reporting period included the following:

- built a new room in the Shop and Equipment Building to store the drill rig;
- fabricated a table on wheels for the blueline machine, moved the machine from the Print Shop into a Shop and Equipment room, from which drilling equipment had been removed, and provided a new vent to expel fumes through the roof;
- rearranged equipment in Print Shop;
- assisted in delivery of a new truck and mounting of the drill rig on it;
- created offices for the new Hydrogeology Research Laboratory in the Annex;
- built a mixing mill for the Industrial Minerals and Metals Section;



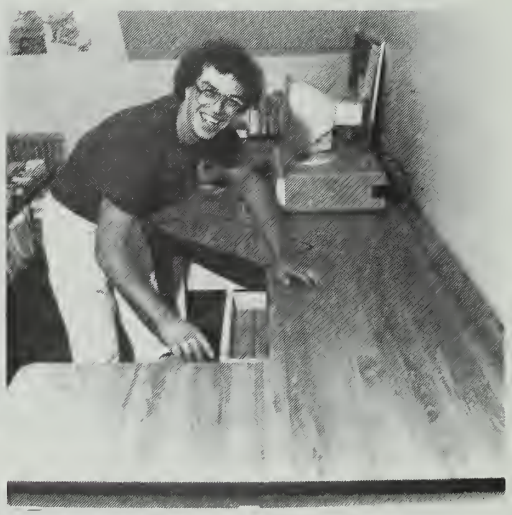
A



B



D



C

(A) Artist Barbara Stiff, Publications, Graphics, and Photography Unit, prepares camera-ready copy for a Survey publication; (B) Larry Ritchie, printing specialist, inspects the new offset duplicator; (C) Michael Dodd, Technical Design, Operations, and Maintenance, installs one of eight custom-built computer tables he produced in the shop. (D) Joseph Kaczanowski, instrument specialist in the Technical Design, Operations, and Maintenance Unit, lubricates the bellows of an enlarger in the darkroom.

- built four acrylic boxes for an experimental vessel at the clay liner project;
- built six stilling wells used in the clay liner experiment;
- built a stand for a digitizing board frame;
- built guide tubes for mine drills;
- prefabricated well protector covers with locking devices;
- fabricated 60 surveying monuments;
- constructed a base for cutting vibracore pipe and photography stand; assembled the vibracore apparatus;
- constructed two chromatography columns;
- fabricated a stand for a velocity meter;
- built a fathometer transport and storage box;
- built map storage racks;
- fabricated several light tables;
- built a stand for the plastic lamination machine;
- shortened the boat trailer tongue; reworked and rewired the trailer;
- built a table for a laboratory oven and clamping racks;
- fabricated a flowmeter and pressure gauge rack;
- built mail boxes;
- constructed a laboratory vacuum bench;
- built several desk organizers;
- built a liquid nitrogen dispensing line for the scanning electron microscope;
- built a dozen bookcases;
- designed and built eight computer work stations;
- assisted in filling drill holes created during the Superconducting Super Collider research.

The drill rig operation is now under the jurisdiction of the Technical Design, Operations, and Maintenance Unit; one of the Unit's staff has been named drill rig operator for the Survey. He has been scheduled to attend a school for rig operators in the fall of 1989.

A total of 315 repair, fabrication, moving, maintenance, and other jobs were completed to fill internal work orders during this reporting period--78 more work orders than were generated for FY88. This total does not reflect the many jobs performed in response to verbal requests, notes, and regular maintenance procedures that are interspersed with the more elaborate shop work.

Electronics Shop

The electronics shop provided support to all Branches in electrical and electronic repairs, maintenance, and installations. This past year, 158 internal work orders were processed, amounting to an increase of 58 requests over the previous reporting period.

Besides moving, extending, and repairing exchanges on many Survey telephones, installing new energy-efficient lights, and updating wiring in display cases outside rooms 203, 207 and 222, the shop solved problems and repaired a variety of electrical and electronic equipment. For example, malfunctions were corrected in or repairs made to multichannel analyzers, magnetic separators, the constant voltage regulator of an X-ray unit, the electrical magnet power regulator for the mass spectrometer, and a meter on the Scintag X-ray diffraction instrument. Serial and prime lines were also run between floors and rooms to make 17 lap-link connections between computers.

Of special value to the Survey is the staff's ability to repair field equipment for rapid turnaround to field use and to maintain old equipment for research purposes. These services save the Survey thousands of dollars each year, while providing invaluable services to support scientific research.

Automotive Section

Servicing of and record keeping on the Geological Survey's fleet of 23 vehicles and the Illinois Natural History Survey's fleet of 48 vehicles is the responsibility of the automotive staff. Because these vehicles are driven well over 100,000 miles, some over rough terrain during field work, their maintenance and repair is of vital concern to the Surveys. During this reporting period, two new

vehicles were acquired by the Survey: a 1989 Chevrolet station wagon replaced a 1980 Dodge Aspen sedan and a 1989 Dodge van replaced a 1983 Dodge van.

Applied Research Lab Shop

In the last working year, the machine shop at the Applied Research Lab was dedicated primarily to sponsored research work. These contract projects required design and basic installation of equipment and followthrough maintenance by the Shop. Evaluation and incorporation of the most efficient equipment to aid the project preceded actual installation. Considerable effort was spent on revamping old parts, or designing and constructing or purchasing new parts. Shop staff also undertook general management and maintenance of the building's equipment, including an inventory and evaluation. The Technical Design, Operations, and Maintenance Unit of the Administrative and Technical Branch collaborates in repair, modification, and maintenance of equipment and provided design assistance.

EDUCATIONAL EXTENSION

Teaching resources A revised edition of the listing "Resources for the Teaching of Geology from the Illinois State Geological Survey" was distributed during November and December to all of the approximately 8,300 schools recognized in Illinois.

Geological science field trips During the year, the Educational Extension Unit hosted field trips in the Forrest area on October 8, 1988, near Wolf Lake on November 5, near Newton on April 15, 1989, and at Savanna on May 20. A total of 471 people attended these trips, including 133 elementary, high school and college students, 68 teachers, and 250 other persons. The Newton field trip emphasized recent studies by a Survey geologist on the stratigraphy of the Pennsylvanian rocks in the area; the Savanna field trip examined faulting and folding in Silurian and older rocks and evidence of the Pleistocene glaciations revealed in the surficial deposits despite the fact that this part of the state was never covered by the continental glaciers.

Groundwater protection education The head of Educational Extension and the assistant to the Chief represented the Illinois State Geological Survey on the Education Subcommittee of the Interagency Coordinating Committee on Groundwater (ICCG). The subcommittee plans and coordinates groundwater education activities of the member agencies. As a major contribution to the State's groundwater education effort, Survey staff compiled a slide/audio tape lecture, "Groundwater - Protecting Our Invaluable Hidden Resource," to introduce the basic concepts of groundwater geology, the possible causes of groundwater contamination, and the actions that individuals can take to protect groundwater. Thirty copies of the show were prepared and distributed to member agencies of the ICCG and to other agencies and individuals, including the Winnebago County Health Department and the McHenry County Health Department, who provided assistance in the development of the show. Between its release in April 1989 and the close of the fiscal year, copies of the slide show have been loaned to 8 agencies or individuals and several have been sold. Additional copies of the slide and tape show will be reproduced for sale during fiscal 1990.

Displays Groundwater protection was featured at the State Fair display. Other displays about Survey research and service were prepared for the semi-annual meeting of county officials in Springfield and for the annual conservation weekend at Market Place Mall in Champaign.

The Publications, Graphics, and Photography Unit developed a 44-foot display entitled, "ISGS Maps the Future of Illinois," with contributions from Survey scientists. The head of the Educational Extension Unit, the Public Liaison Officer, and the Chief presented the display at the International Geological Congress in Washington, DC, from July 9 to 19, 1989. The display featured examples of major maps that have been computerized in the Geographic Information System (GIS), signifcant derivative maps that have since been produced with the GIS, and current geologic mapping programs including CUSMAP, COGEOMAP, geology for planning, and groundwater resource and protection studies. The Satellite Image Map was also featured.

GEOLOGICAL RECORDS AND SAMPLES LIBRARY

Despite the continued downturn in the oil and gas industry, the overall volume of data contributed to and handled by the Geological Records Unit increased significantly in 1988-89 (see table), primarily as a result of revitalized efforts to obtain and enter water well records into the system.

Effective December 1, 1988, the resources of the Geological Records Unit and Geological Samples Library were combined as part of a general Survey reorganization. Geological Records was functionally divided into three working groups: Well Records Task Force (oil and water records); Records (oil and water); and Copy Services. The Samples Library Office (room 101) and Sample Study Lab (room 103) at the Natural Resources Studies Annex have been relocated to room 102E Natural Resources Annex. As a result of this move, the Sample Library is still able to provide ample study space for visitors to the facility.

GEOLOGICAL RECORDS UNIT

The Geological Records Unit is the repository for drilling records in Illinois, including oil and gas wells, water wells, engineering borings, and miscellaneous test holes. This database has long been of value to the oil, coal, aggregate and construction industries, hydrogeolgists, engineers, land-use-planners, academic institutions, land owners, general public, and staff in addressing numerous problems requiring subsurface geological information.

Effective January 1, 1989 the Illinois Department of Mines and Minerals initiated changes in the rules for issuing oil well permits based on compliance. To meet their requirements, the Geological Records and Computer Research and Services Sections have made a number of changes in the monthly noncompliant operators list. Geological Records and the Department of Mines and Minerals also increased their interaction and communications with operators regarding noncompliance.

Visitor space to study well records in room 227 Natural Resources Building was expanded as a result of reducing space needs for the pending file having transferred it into the main files. Additional table space was created for visitors and staff.

While a backlog of older water well records exists, entry of recent water well records and information exchange with the Illinois State Water Survey is current. A database program similar to that used by the Water Well Records Task Force is being used to input water records submitted to either or both Surveys. All of the new water well permits and logs are filed and are accessible to visitors and the staff of both Surveys.

Geological Records staff assists visitors and Survey scientists with requests for information regarding drillhole records on file. The staff also receives and fills orders for copies of logs and other well data. Use of the well records by visitors and staff during the reporting period decreased by 103 records as compared to the previous year. Orders for well records also decreased (1,719 in FY89 compared with 2,710 the previous year); therefore revenues generated from the copy service decreased.

Pending File Task Force

The Pending File Task Force was formed February 1, 1988, to process a backlog of 6,700 completed oil well files. Meeting the projected completion date of December 1, 1988, required processing records at the rate of 670 per month. The Task Force successfully completed the transfer of these 6700 records on August 22, 1988 (4 months ahead of schedule). The net result of this effort by the six-member task force was 10,299 completed files moved in 13 months. An additional 7,601 incomplete records had header information entered into the Survey's database and new file folders were interfiled in the main records collection. The processing of completed oil and gas files is current.

Water Well Records Task Force

Effective November 1, 1988, a task force was formed to sort, organize, and enter into the computer database information from some 27,300 water wells. The task force is using the CONQuEST data entry program developed by the Survey's Well Database Unit. To date 12,486 records have been processed, reducing the backlog to 14,814. Additional file space has been created to make these records accessible to staff and public during the entry process. On May 1, 1989, the Task Force was expanded to four fulltime members.

Additional data have been added to the Geological Records water database and a model established for future water database comparisons. The following table summarizes GRU activity.

Annual Statistics of the Geological Records Unit

Data Acquisition		
Basic data	**1987-88**	**1988-89**
Oil permits	2,462	1,196
Water permits	11,824	14,689
Plugging affidavits - oil	2,259	1,727
Plugging affidavits - water	1,323	2,662
Logs		
Electric logs	1,003	824
Micro logs	212	247
Radioactivity logs	1,485	1,424
Miscellaneous geophysical logs	62	83
Total geophysical logs	*2,762*	*2,578*
Drillers logs	241	219
Drilling time logs	213	368
Company sample and core studies	44	64
Geologic tops	79	155
General data (completion data)	1,958	1,730
Water well and test hole logs	5,914	8,928
Miscellaneous	83	92
Total new logs received	*8,532*	*14,134*

Cumulative Totals

Collections	**FY89**	**Cumulative to June 30, 1989**
Processed drill hole records	493	286,905
Books of processed drillhole records	60	836
Skeleton logs (records prior to 1920)		17,920
Books of skeleton logs		40
Books of confidential logs		15
Books of out-of-state logs		14
Books of misc drill hole records		9
Geophysical logs	2,578	124,245
Coal pluggings	620	21,157

Service Activities	**1987-88**	**1988-89**
Visitor days	1,511	1,204
Files used by public and staff	73,726	73,623
Phone calls	3,516	3,345
Total orders processed	2,710	1,719

Annual Data Acquisition

Oil well permits issued (1,196) by the Department of Mines and Minerals decreased by 1,266 from last years 2,462. While permits decreased, data acquisition for the reporting period increased due to the Department of Mines and Minerals noncompliant program. Oil well plugging affidavits decreased during the reporting period. Of the 4,389 affidavits received, 1,727 were for oil wells (compared to 2,259 for oil the previous year) and 2,662 for water wells (compared to 2,259 the previous year). Total new logs received (14,134) increased by 65 percent.

GEOLOGICAL SAMPLES LIBRARY

The Survey Geological Samples Library manages one of the largest physical collections of geological samples in the United States. The Samples Library staff receives, processes for storage, and archives these important collections as mandated by Illinois Statute (chapter 96 , Natural Resources Conservation of Oil and Gas). The Geological Survey began collecting these samples in the early 1900s when the U.S.Geological Survey provided a series of drill cuttings to the State Geologist. Today, this unique repository houses cores and cuttings that represent billions of dollars invested in Illinois by petroleum and mining and engineering companies. The collection attracts users from across the country, encouraging potential investment in Illinois by both in-state and out-of-state companies and providing a database with which to address environmental and resource issues.

Visitors and staff referred to our files 241 times (225 less than in 1988) and studied 587 sets of samples or core (351 less than 1988). Visitors to the Annex facility represent a wide range of geologic interests. Independent consultants and representatives of major oil companies, universities, and government agencies are typical visitors to the Samples Library. Of the 140 (130 less than 1988) visitors to the Samples Library, 44 percent were from out-of-state. The decline in visitors reflects the continued decrease in oil exploration.

Samples Library personnel assemble rock and mineral kits for distribution to Illinois schools. A 35-specimen set is designed to familiarize teachers and students with rocks, minerals and fossils of Illinois. In the past year, 222 specimen kits were assembled (23 less than the previous year) and 56 orders were filled for the reconditioning of sets already distributed to schools.

The Samples Library received a new Raytech Model CS18a core saw during FY89. The saw has been installed in the core saw room of the Annex facility. Survey staff received operating instructions and other training from Raytech. This new saw replaces an outdated core saw and will enhance the capabilities of the Library and the value of the core collection.

Effective July 1, 1988, the Illinois State Geological Survey ended its contract with the Evansville Sample Cut for sample processing. All processing will be done within existing facilities at the Survey. The Samples Library staff has been notifying the drilling industry that samples requested on permits should be delivered or shipped prepaid to the Illinois State Geological Survey. The Survey allowed a 6-month transition for the change, and industry response has been positive.

Samples Acquisition

Cuttings Oil and water well cuttings added to the Geological Samples Library during the reporting period increased the total footage of cuttings to 741,702,387 feet.

During FY89, the permanent file of the Samples Library acquired 218 sets of well sample cuttings, representing more than 253,140 feet of drilling. These samples are contained in 377 boxes and occupy an additional 9 linear feet of storage space. One hundred sixty one sets of well cuttings were requested from permits issued last year compared with 179 the previous year. The Samples Library files of 66,643 sets of well cuttings are stored in 101,849 boxes and utilize 1,418 linear feet in a 3,780 square foot area of the Samples Library. Only 5 percent of the available storage capacity for cuttings remains.

Samples from an additional 181 oil and water wells (118 more than the previous year) await processing. At present, the interval between receipt and permanent processing is 10 months, a 6-month increase over last year. Additions to our permanent files consisted of 66 oil test sets from rotary drill wells washed, 21 washed sets purchased from the Evansville Sample Cut, and 131 water wells. Forty-seven percent of the 161 oil well cuttings requested were received last year.

Cores Rock cores from oil and mineral borings added to the Geological Samples Library during the reporting period increased the total footage of core to 937,891 feet. During the reporting period 72 cores representing an initial 17,311 feet of drilling were collected, examined, and processed into the permanent files. This years additions are housed in 1,700 cardboard core boxes assembled by GSL staff. As part of the wrap up of the Superconductor Super Collider project, 40 holes representing 17,609 feet of drilling were added to the permanent collection. An additional 11 holes representing 3,530 feet of drilling in Jo Daviess County and 39 Oil and Gas Tests representing 3,590 feet of drilling were received and placed in temporary storage. These cores represent a significant addition to the core collection. Space for core storage is 92 percent filled. The entire collection of 13,424 sets of core on permanent file is stored on steel racks in an area covering approximately 4,300 square feet of the Samples Library.

Other Sample Collections

In cooperation with the Industrial Minerals and Metals Section, an additional 2,032 samples were split and prepared for insoluble residues. The Survey staff generates a large volume of research material. Geological Samples Library staff receives, sorts, and files these materials in the Staff Research Collections storage area of the Samples Library. Some 3,000 items, mostly analytical samples, were added to this collection bringing the total to more than 35,000 individual research samples on file at the Annex.

The Illinois State Geological Survey provides sample bags for the collection of well sample cuttings requested on permits issued by the state. During the past reporting period, the Samples Library supplied drillers and operators with 25,000 sample bags for requested well cuttings (11,250 less than previous year).

CAPITAL PROJECTS FACILITIES UPGRADE

Three Capital Development Board (CDB) projects, which began in FY87, are underway. They are scheduled for completion January 1990. The projects are described as follows:

Description	Fund	Cost
Renovation of the Natural Resources Building, the Natural Resources Annex, and the Applied Research Building to upgrade lab facilities. 244-030-003	CDB	$470,000
Renovation of the Natural Resources Building and Studies Annex and Applied Research Building to upgrade laboratory facilities. 244-030-003	CDB	$316,000
Installation of a fire/smoke alarm system in the Natural Resources Building. 244-030-004	CDB	$308,000

Work consists of the following:

- replace chemical fume hoods and relocate motors and fans to the roof or attic so that fume vents have negative internal pressure throughout most of their run from the workspace to the exit vent;
- relocate or install shower drench stations;
- install eye-face wash stations;

- replace laboratory benches and sinks that have corroded plumbing, unsafe and inadequate electrical service, corroded and porous work surfaces, inadequate or unsafe utility service; replace and improve utilities;
- install wall cabinets to provide enclosed storage of reagents and glassware, especially where inadequate shelving and other storage space for essential laboratory equipment has resulted in work space being used for storage;
- replace old incandescent lights with fluorescent lights to help keep laboratories cool, to avoid the possibility of igniting explosive gases in the event of lamb globe breakage, and to increase the brightness of illumination in the laboratories;
- repaint the laboratories with light colors to further increase the apparent brightness of room illumination, to remove and rehabilitate peeling paint, and to clean 35- to 45-years of accumulated grime and dust from the walls, ducts, and pipes;
- install a make-up air system;
- remove asbestos;
- install fire/smoke alarm system for the Natural Resources Building.

Laboratories in two buildings are included in the work:

Natural Resources Building

Room number	Lab name
318A&B	Volatile Storage Room (acid & salt)
323	Spectrochemical Preparation
325	Atomic Absorption Lab
326	Radiochemistry Lab
329	Rock Analysis
335	Microbial Geochemistry
363	Organic/Analytical/Storage
365	Organic Geochemistry
369	Organic Geochemistry
371	Organic Geochemistry
20	Isotope Chemistry
226	Coal Paleobotany
302	Isotope Geochemistry
311	Oil & Gas Analysis Lab
313	Optical Emission Lab
324	Microbial Geochemistry
331	Furnace Room
338	Clay Mineralogy Lab
Annex	
102B&C	Paleontology Lab
202	Environmental Geology

This total undertaking has lagged primarily due to problems of incorporating asbestos abatement into the regular work schedule. Major material and equipment items have now been received and construction is moving toward targeted completion the beginning calendar year 1990.

FY90 Capital Projects

An approved FY90 capital project will continue the Natural Resources Building Laboratory Upgrade at a cost of $630,000.

The FY90 upgrade will include the following laboratories:

Natural Resources Building

Room number	Lab name
5	Engineering Geology
20	Isotope Geochemistry
22	Core Laboratory
26	Rock Grinding
31	Industrial Minerals
33	Industrial Minerals
207	Mining Geology
217	Coal Petrography
223	Low Temperature Ashing
301	Petrography
302	Isotope Geochemistry
311	Oil & Gas
325	X-Ray Fluorescence
331	Furnace Room
335	Microbial Geochemistry
364	Mass Spectrometer
403	Photo Lab
425A	Groundwater Lab
425B	Groundwater Lab
435	Groundwater Lab

Honors

HONORS

Prizes, Medals, High Offices, and Other Honors

Keros Cartwright received a certificate of appreciation from the Director of the U.S. EPA for his service on the EPA's Science Advisory Board.

Donald R. Dickerson received his credentials as a "Certified Professional Chemist" from the National Certification Commission in Chemistry and Chemical Engineering, sponsored by the American Institute of Chemists. He was also named an Honorary Life Member of the Illinois Junior Academy of Sciences in May 1989.

Beverly L. Herzog received her credentials as a "Certified Ground Water Professional" through the Association of Ground Water Scientists and Engineers and as a "Certified Professional Geologist" through the American Institute of Professional Geologists. She was also named an "Outstanding Young Woman of America" for 1988 by the Outstanding Americans' organization.

The paper "Changes in Volatile Organic Chemical Concentrations After Purging Slowly Recovering Wells," by **Beverly L. Herzog, Sheng-Fu Joseph Chou, John R. Valkenburg, and Robert A. Griffin**, was cited as the best paper published in 1988 in *Ground Water Monitoring Review*.

John P. Kempton received the Distinguished Achievement Award of the Illinois State Geological Survey in October 1988. Few other scientists in the history of the Survey have exerted so profound an influence on the course and character of its research and service programs.

"Geologic Applications of ARC/INFO: Examples from Illinois," the poster presented by **Robert J. Krumm, Robert R. Pool, George D. Graettinger, Gail D. Taylor, Lisa R. Smith, E. Donald McKay III, and Anne L. Erdmann** was named the "Most Analytic Poster Session" at the ESRI ARC/INFO Users' Conference in Palm Springs, California, in May 1989. The poster was nominated by conference participants and selected from nearly 200 posters at the meeting.

Samuel V. Panno received his credentials as a "Certified Ground Water Professional" by the Association of Ground Water Scientists and Engineers.

Kerry M. Riley was awarded a Certificate of Merit by the Illinois State Geological Survey for his volunteer assistance and advice in the purchase and set-up of microcomputer systems.

Paul R. Seaber was elected a Commissioner of the North American Commission on Stratigraphic Nomenclature representing the Geological Society of America for the years 1989-1991. He was also elected Second Vice Chairman of the Hydrogeology Division and Co-Chairman of the Division's Program Committee for the 1989 annual meeting of the Society to be held in St. Louis.

Activity Measures

ACTIVITY MEASURES

All Illinois state agencies are required to provide activity measures as part of their annual budget presentations to the legislature. Selected activity measures also are included in the Governor's report on the Illinois state budget. Internally, we use a wide range of activity measures to gauge how effective we are at reaching the public with our information and services. The measures also are helpful indicators of where our research and service staff are applying their greatest energies, and to what degree we may need to adjust or reshape our program, budget or organization. The table at the end of this section shows selected activity measures, distributed by program areas.

This year, the Illinois State Geological Survey underwent a significant reorganization, shifting the administrative positions of several programs. Of greatest significance to the tabulation of activity measures was the change in the structure of the groundwater research and service programs. Creation of the Groundwater Resources Section under the Mineral Resources and Engineering Branch moved most of the counting of "groundwater possibility" and "high-volume well" reports from the Environmental Research program to the Mineral Resources program. This shift is clearly reflected when the totals for "unpublished reports/memos" in the accompanying table are compared to the values reported last year: the total number is essentially the same as last year, but the programmatic distribution of the count has shifted. This indicates that it may be unwise to directly compare this year's activity measures tabulations to previous years without considering the impacts that reorganization may have had in the distribution of the values.

Because few of our scientists now keep accurate individual logs of telephone conversations, the report of "telephone responses" distributed by program has been dropped from the activity measures table. Instead the estimated total number of long-distance calls charged to the Survey is reported below. This tabulation is based on a 3-month sampling of long-distance calls billed to the Survey by the University

Measures

Research Activities Our scientists reported 136 state-funded research and service projects in progress during the year, 30 fewer than last year's total. Of these, 64 were in the area of Mineral Resources and Engineering, 32 in Environmental Geology, and 40 in General and Basic Research. A total of 98 externally funded research projects were reported in progress during the year, of which 26 were in the area of Mineral Resources and Engineering, 55 in Environmental Geology, and 17 in General and Basic Research. During the report year, our scientists submitted 62 research proposals to various sponsoring agencies, one-half the number submitted last year. The reduced number of new proposals may reflect the continuation of several complex, long-term projects begun last year, based on proposals submitted the previous year and the focus required on state-funded research and service projects. About 75 percent of the proposals we submit are funded by the sponsor.

To present our research information to the public and the scientific community, we published a total of 242 new articles, reports, abstracts and maps in our own series and in other forums such as scientific journals, proceedings volumes, guidebooks, and final contract reports. Although this number is somewhat lower than last year's number of publications, the number reported last year included the 80 coal mine maps which had been released that year, despite the fact that those maps were not listed in last year's "Publications" volume of the annual report. The maps are listed in this year's volume, but are not included among the 242 publications counted. The Information and Technical Services Unit sold 8,559 copies of our publications and 2,151 of our maps, and distributed 16,095 publications and 489 maps free. The total of 27,294 items distributed is about 35 percent less than last year's total. The reduced number of publications not distributed is caused primarily by our firm effort to reduce the size of mailing lists. Reducing free distributions helps to control the cost of publishing in the face of rising costs for paper and other materials. In addition to our own publications, we sold 17,113 copies of U.S. Geological Survey topographic map products and distributed 4,600 copies of these products gratis.

Public, Government, and Industry Services

• ***Information Responses*** We hosted 7,219 visitors this year to provide scientific information. We also sent out 1,737 letter responses to inquiries and made an estimated 19,000 long-distance telephone calls to exchange information. In addition to these out-going calls, the Information Office received an estimated 10,900 telephone calls requesting information about the geology and mineral resources of Illinois. The number of visitors to the Geological Survey rose almost 16 percent compared to last year; mostly to the Information Office under the Technical and Administrative Services Branch. The sharp drop in the number of visitors reported by the Environmental Geology area may reflect, in part, the move of groundwater resources to the Mineral Resources Branch. About 1,200 visitors used the Geological Records Unit facilities during the year, an increase of slightly more than 100 over last year. A total of 2,912 well log copies were sold and 266 were distributed free. In addition, GRU sold 17,558 single sheet copies of well records and distributed 2,593 free copies. The Geological Samples Library hosted 140 external visitors and distributed 266 sample sets to those visitors.

• ***Identifications, Analyses, and Reports of Results*** To conduct their various research and service projects during the year, ISGS scientists completed at least 34,632 separate elemental determinations on 5,796 samples of rock, soil, mineral, brine, coal, water or other materials. In addition, our scientists completed X-ray mineralogical determinations on 2,077 samples, analyzed 366 samples in the scanning electron microscope, made 404 microscopic examinations of samples to identify mineralogy/petrology, coal petrology, palynology, micropaleontology or other characteristics, made thermogravimetric measurements on 170 samples, determined the acid-insoluble residue content of 200 carbonate rocks, made 163 hand specimen identifications for visitors determined the particle size distribution or suspended sediment content of 3,965 samples and measured geotechnical properties of 55 samples. In the field, our scientists examined 199 cores of surficial and/or bedrock materials and 305 sample sets of drill cuttings, measured 147 stratigraphic sections conducted 54 electrical earth resistivity surveys, 34 seismic surveys and geophysically logged 29 boreholes. To report the results of these analyses, and for other purposes, our scientists prepared 699 unpublished technical reports, including 180 groundwater possibility reports, 101 high-volume well reports, 15 waste disposal site reports, 7 ground subsidence investigation reports and 5 deep injection well reports. Staff members of the Computer Research and Services Section and other scientists completed 112 data entry projects, wrote 1,239 computer programs, digitized 1,018 maps, and plotted 2,426 digital map files.

Continuing Scientific/Educational Contributions Geological Survey staff members presented papers at scientific meetings, made speeches or other informational presentations at public meetings, discussed posters, participated in field conferences to consider geologic problems first-hand and otherwise transferred information to fellow scientists and the public on 457 occasions during the year, including 76 interviews with print, radio and television reporters. In addition, our scientists either taught or participated in 255 workshops, seminars and classes, including a small number of presentations to elementary, high-school and college classes. These specific occasions are all tabulated in the "Recognition and Service" section of the Annual Report. In addition, our scientists assisted graduate students in geology and other subjects across the entire state on 329 occasions during the year. The Educational Extension Unit distributed 244 partial or complete rocks and mineral sets to schools, 47 topographic map sets, 76 coal ball slices, 80 topographic map guides, 1,057 copies of various Education Series booklets, 2,500 copies of field trip guide leaflets. A total of 8,300 schools in Illinois received copies of our "Resources for Teaching Geology Available from the Illinois State Geological Survey. These numbers are included in the total reported for the Unit under "Unpublished Reports" in the table.

Public, Industry, Government Contributions Survey staff members serve on 34 advisory committees for national, state and local government. In addition, some 58 staff members hold offices in various scientific and professional societies, or provided services to those societies that ranged from reviewing manuscripts and proposals to chairing meetings and publishing newsletters. Our scientists presented oral or written testimony to local, state or national governmental or advisory bodies on 29 occasions during FY 89.

Activity Measures 1988-89

	Mineral Resources	Environ Geology	General & Basic Res	Admin Services	Total
Reports/Maps					
• Published	91	81	58	12	242
• Distributed					49007
Unpublished Reports	428	204	67	12330	13029
Visitors and Office Conferences	2041	339	395	4444	7219
Letter Responses	705	330	192	510	1737
Talks, Posters Displays, Interviews	157	195	78	27	457
Workshops, Classes Seminars	51	81	102	21	255

Financial Report

FINANCIAL REPORT

Fiscal Year 1989

Appropriated funds Of the appropriated FY89 funds totaling $6,083,400 (tables F-1 and F-2), the Illinois State Geological Survey expended all but $1,000 (.02%) of General Revenue monies and $217,300 (62%) in the Natural Resources Information Fund. Expenditures in the Natural Resources Information Fund were intentionally light as revenues did not fully support the appropriation in FY89. Funding from other sources was necessary to provide for needed telecommunications and equipment purchases.

Allocated funds Of the allocated FY89 funds totaling $482,800 (tables F-3, F-4, and F-5), the Illinois State Geological Survey expended all monies in the Hazardous Waste Research Fund and Repair and Maintenance. Lapses occurred in LUMP $2,400 (1.49%) and Build Illinois Repair and Maintenance $240 (.43%).

Table F1 FY89 financial statement for the Illinois State Geological Survey General Revenue Fund: July 1, 1988, through September 30, 1989

Line item	Appropriation for FY89	Transfers	Vouchered to date	Outstanding obligations this date
Personal Services	$4,769.5	$0.0	$4,769.5	$0.0
Retirement Contributions	492.1	0.0	492.1	0.0
Social Security Contributions	7.5	0.0	6.8	0.0
Contractual Services	96.2	(1.9)	94.3	0.0
Topomapping	19.0	0.0	19.0	0.0
Travel	37.7	0.0	37.6	0.0
Commodities	70.0	0.0	69.9	0.0
Printing	34.0	0.0	34.0	0.0
Equipment	44.0	0.0	44.0	0.0
Computer-Based Research	44.9	0.1	45.0	0.0
Telecommunications	54.0	1.5	55.5	0.0
Operations of Auto Equipment	34.0	0.3	34.2	0.0
GeoMapping - Other Expenses	24.8	0.0	24.8	0.0
TOTALS	$5,727.7	$0.0	$5,726.7	$0.0

Table F2 FY89 financial statement for the Illinois State Geological Survey Natural Resources Information Fund (NRIF): July 1, 1988, through September 30, 1989

Line item	Appropriation for FY89	Vouchered to date	Outstanding obligations this date	FY89 lapse
Lump Sum - Operating Expenses	$354.7	$138.1	$0.0	$216.6
Refunds	1.0	0.3	0.0	0.7
TOTALS	$355.7	$138.4	$0.0	$217.3

NRIF revenue July 1, 1988 through June 30, 1989 was $118.3.

Table F3 FY89 financial statement for the Illinois State Geological Survey Lands Unsuitable for Mining Program: July 1, 1988, through September 30, 1989

Line item	Allocation for FY89	Funds held by DMM	Transfers	Available allocations	Outstanding obligations this date	FY89 lapse
Personal Services	$137.8	($1.0)	$0.0	$136.8	$0.0	$0.3
Retirement Contribution	0.0	0.0	0.0	0.0	0.0	0.0
Social Security Contributions	0.0	0.0	0.8	0.8	0.0	0.0
Group Insurance	7.2	0.0	0.0	7.2	0.0	1.1
Contractural Services	2.3	0.0	(0.8)	1.5	0.0	0.3
Travel	7.0	0.0	0.0	7.0	0.0	0.7
Commodities	0.4	0.0	(0.4)	0.0	0.0	0.0
Printing	0.0	0.0	0.0	0.0	0.0	0.0
Equipment	0.0	0.0	0.0	0.0	0.0	0.0
Computer Based Research	4.7	0.0	0.0	4.7	0.0	0.0
Telecommunications	1.3	0.0	0.4	1.7	0.0	0.0
Operations of Auto Equipment	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS	$160.7	($1.0)	$0.0	$159.7	$0.0	$2.4

Table F4 FY89 financial statement for the Illinois State Geological Survey Groundwater Protection Act: July 1, 1988, through September 30, 1989

Line item	Allocation for FY89	Reserve	Available allocation	Vouchered to date	FY89 lapse
Lump Sum	$135.0	($67.5)	$67.5	$67.5	$0.0
TOTALS	$135.0	($67.5)	$67.5	$67.5	$0.0

Table F5 FY89 financial statement for the Illinois State Geological Survey Miscellaneous Funds: July 1, 1988, through September 30, 1989

Line Item	Allocation for FY89	Vouchered to Date	Outstanding Obligations This Date	FY89 Lapse
Repair & Maintenance	$5.0	$5.0	$0.0	$0.0
Build Illinois Equipment	125.9*	125.9	0.0	0.0
Building Illinois Maintenance	56.2	56.0	0.0	0.2
TOTALS	$187.1	$186.9	$0.0	$0.2

ILLINOIS STATE GEOLOGICAL SURVEY STAFF LIST

November 1, 1989

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ILLINOIS STATE GEOLOGICAL SURVEY

RECOGNITION AND SERVICE

July 1988 to June 1989

HONORS AND AWARDS

Prizes, Medals, High Offices, and Other Honors

Keros Cartwright received a certificate of appreciation from the Director of the U.S. EPA for his service on the EPA's Science Advisory Board.

Donald R. Dickerson received his credentials as a "Certified Professional Chemist" from the National Certification Commission in Chemistry and Chemical Engineering, sponsored by the American Institute of Chemists. He was also named an Honorary Life Member of the Illinois Junior Academy of Sciences in May 1989.

George D. Graettinger was elected to Alpha Lambda Delta, a national scholastic honorary society for first-year graduate students.

Beverly L. Herzog received her credentials as a "Certified Ground Water Professional" through the Association of Ground Water Scientists and Engineers and as a "Certified Professional Geologist" through the American Institute of Professional Geologists. She was also named an "Outstanding Young Woman of America" for 1988 by the Outstanding Americans' organization.

The paper "Changes in Volatile Organic Chemical Concentrations After Purging Slowly Recovering Wells," by **Beverly L. Herzog, Sheng-Fu Joseph Chou, John R. Valkenburg, and Robert A. Griffin**, was cited as the best paper published in 1988 in *Ground Water Monitoring Review*.

John P. Kempton received the Distinguished Achievement Award of the Illinois State Geological Survey in October 1988. Few other scientists in the history of the Survey have exerted so profound an influence on the course and character of its research and service programs.

"Geologic Applications of ARC/INFO: Examples from Illinois," the poster presented by **Robert J. Krumm, Robert R. Pool, George D. Graettinger, Gail D. Taylor, Lisa R. Smith, E. Donald McKay III, and Anne L. Erdmann** was named the "Most Analytic Poster Session" at the ESRI ARC/INFO Users' Conference in Palm Springs, California, in May 1989. The poster was nominated by conference participants and selected from nearly 200 posters at the meeting.

Samuel V. Panno received his credentials as a "Certified Ground Water Professional" by the Association of Ground Water Scientists and Engineers.

Kerry M. Riley was awarded a Certificate of Merit by the Illinois State Geological Survey for his volunteer assistance and advice in the purchase and set-up of microcomputer systems.

Paul R. Seaber was elected a Commissioner of the North American Commission on Stratigraphic Nomenclature representing the Geological Society of America for the years 1989-1991. He was also elected Second Vice Chairman of the Hydrogeology Division and Co-Chairman of the Division's Program Committee for the 1989 annual meeting of the Society to be held in St. Louis.

Billy A. Trent has received the first Psi Iota Xi scholarship for the 1989-90 academic year from the English Department, University of Illinois. The scholarship is awarded competitively to a senior student in the english department of high academic standing.

Lawrence Wu has been nominated for Sigma Xi, the international scientific honorary society.

Graduate Degrees Earned by Staff

Anne L. Erdmann was awarded the degree of Master of Science in Geophysics from the Department of Geology and Geophysics, University of Minnesota, Minneapolis, in December 1988.

SCIENTIFIC AND EDUCATIONAL CONTRIBUTIONS

Papers/Abstracts Presented at Scientific Meetings

Chen-Lin Chou attended the 197th meeting of the American Chemical Society and presented the paper, "An Overview of the Geochemistry of Sulfur in Coal."

Mei-In (Melissa) Chou attended the meeting of the eastern section of the American Association of Petroleum Geologists, September 1988, in Charleston, West Virginia, where she participated in a core analysis workshop and presented the poster paper "Rock-Eval Data Relating to Oil Source Potential of Shales of the New Albany Group (Devonian-Mississippian) in the Illinois Basin." She also attended a meeting of the Kentucky Oil and Gas Association in Lexington, Kentucky, June 1989, where she presented the invited paper, "Organic Geochemistry of Crude Oils in Illinois Based on Gas Chromatography Analysis."

Michael J. Chrzastowski attended the North Central Section meeting of the Geological Society of America in Notre Dame, Indiana, April 1989, where he presented, "Changes in coastal Sedimentary Dynamics Resulting from Water-Level Change and Altered Coastal Geography," and "Hydrographic Monitoring Program in the Vicinity of North Point Marina on the Illinois Lake Michigan Shore." He also participated in a one-day field trip on the depositional and erosional history of the Indiana lakeshore held in conjunction with the meeting.

Joseph A. DeBarr presented the paper, "Combustion of Coal-Derived Fuels by Thermogravimetric Analysis. II. Effect of Particle Size on Burning Profiles," at the 17th annual conference of the North American Thermal Analysis Society in Lake Buena Vista, Florida, October 1988.

Gary B. Dreher presented the paper, "Factors Affecting Management of ISGS Aggregate Flotation Waste Solids," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988.

Wayne T. Frankie presented the paper, "Hydrocarbon Exploration in Mississippian Carbonates, Southeastern Kentucky," at the Twentieth Annual Appalachian Petroleum Geology Symposium, March 1989 in Morgantown, West Virginia.

Joyce K. Frost attended the 1988 Eastern Oil Shale Symposium in Lexington, Kentucky, at the end of November. She presented the paper, "Organic Carbon, Sulfur, and Iron Relationships in the New Albany Shale Group (Devonian-Mississippian), Illinois Basin."

Keith C. Hackley and Carl W. Kruse attended the First Symposium on Advances in Coal Spectroscopy at Snowbird, Utah, June 1989. They presented a paper, "MS Determination of $^{34}S/^{32}S$ for Tracking Forms of Sulfur in Coal Research."

Richard D. Harvey presented the poster,"Online Information on Coal Available at the Illinois State Geological Survey," at the 5th annual meeting of the Society for Organic Petrology in Houston, Texas, November 1988.

Bruce R. Hensel presented the paper, "Quantitative Assessment of Potential for Groundwater Contamination from Municipal Landfill Leachate in Illinois," at the Eleventh Annual Madison Waste Conference in Madison Wisconsin, September 1988.

Beverly L. Herzog attended the International Conference on Advances in Ground-Water Hydrology of the American Institute of Hydrology at Tampa, Florida, November 1988, where she presented the paper, "Scale Effects in Hydrogeologic Experiments."

Carol A. Hindman presented the paper, "An Environmental Application of a GIS for Modeling Networks," at the GIS Symposium, Integrating Technology and Geoscience Applications sponsored by the National Academy of Sciences in Denver, Colorado, September 1988. She presented the same talk at the Great Lakes-Midwest Regional ARC/INFO Users Conference in St. Paul, Minnesota, October 1988, and a poster session by **Colin G. Treworgy and Margaret H. Bargh** on "Use of GIS as a Tool for Geologic Mapping and Analysis." At the Ninth International Symposium on Computer-Assisted Cartography held in conjunction with the annual meetings of the American Congress on Surveying and Mapping and the American Society for Photogrammetry and Remote Sensing in Baltimore, Maryland, April 1989, Ms. Hindman and Mr. Treworgy presented the paper, "Use of a Geographic Information System to Evaluate the Potential for Damage from Subsidence of Underground Mines in Illinois."

Randall E. Hughes and Duane M. Moore presented the poster session, "Further Studies on the Origin, Identification and Quantification of Illite Polytypes," at the 25th annual meeting of the Clay Minerals Society in Grand Rapids, Michigan, September 1988. Following the meeting they participated in a field trip to examine Pennsylvanian outcrops and tills in southern Michigan. On October 29, 1988, Dr. Hughes participated in a field trip sponsored by the Big Rivers Area Geological Society to examine ball clay deposits in western Kentucky and Tennessee.

John P. Kempton presented the paper, "Geological Program to Site the Superconducting Super Collider in Illinois," at the annual meeting of the Geological Society of America in Denver, Colorado, October 1988.

Myrna M. Killey and C. Brian Trask attended the 31st Annual Meeting of the Association of Engineering Geologists, October 1988, where they presented the poster session, "Geotechnical Site Investigation for a 7-GeV Synchrotron at Argonne National Laboratory." They also attended field trips on "Urban Geology of the Kansas City Area" and "Smithville and Blue Springs Dams."

Dennis R. Kolata attended the annual meeting of the Geological Society of America in Denver, Colorado, October 31 - November 3, 1988, where he presented the paper "Tectonic History of the Illinois Basin: An Overview," and the poster presentation, "Correlation of the Upper Ordovician Deicke K-bentonite Bed from the Upper Mississippi Valley to the St. Lawrence Valley, Canada." He and **Michael L. Sargent** also attended a short course on "Quantitative Modeling of Sedimentary Basins" in conjunction with the meeting.

Robert J. Krumm, Robert R. Pool, George D. Graettinger, Gail D. Taylor, Lisa R. Smith, E. Donald McKay III, and Anne L. Erdmann all answered questions and presented discussions for their poster session, "Geologic applications of ARC/INFO - Examples from Illinois," at the 9th Annual ARC/INFO Users Conference sponsored by ESRI in Palm Springs, California, May 1989. At the "GIS Symposium: Integrating Technology and Geoscience Applications," sponsored by the National Academy of Sciences in Denver, Colorado, September 1988, Mr. Krumm presented the paper, "Geologic Applications of an Extensive GIS Database: Examples from Illinois."

Carl W. Kruse presented the paper, "Illinois Basin Coal Sample Program," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988.

Timothy H. Larson presented the poster,"Mapping Soil Thermal Properties in Illinois, USA," at JIGASTOCK 88, the Fourth International Conference on Energy Storage for Building Heating and Cooling and Third International Colloquium on Applied Geothermics in France, October 1988.

John M. Masters and senior author R.H. Fluegeman, Jr., jointly presented their poster on "Paleocene Foraminifera from Southern Illinois: Biostratigraphy and Paleoecology" at the annual mid-year meeting of the Society of Economic Paleontologists and Mineralogists in Columbus, Ohio, August 1988. Following the meeting, Mr. Masters participated in a field trip to examine depositional facies of Wisconsinan ice-sheet materials of the Scioto Glacial Lobe, central Ohio.

E. Donald McKay III attended the "Geographic Information Systems Symposium - Integrating Technology and Geoscience Applications," sponsored by the National Academy of Sciences in Denver, Colorado, September 1988, where he presented the paper, "GIS Utilization by State Geological Surveys: Results of a 1988 AASG Questionnaire."

Edward Mehnert presented the paper, "Investigation of the Hydraulic Effects of Deep-Well Injection of Industrial Waste in Illinois," at the 33rd Annual Midwest Ground Water Conference in Columbus, Ohio, October 1988, and at the International Symposium on Injection Well Technology in Dallas, Texas, May 1989. At the Dallas meeting he also presented the paper, "Evaluation of Hydraulic Monitoring Strategies for Detecting Leakage from an Injection Zone--Numerical Modeling of a Class I Injection Well in Illinois."

Donald G. Mikulic presented the paper, "Konservat Lagenstatten in the Silurian of North America," and the poster, "An Exceptionally Preserved Silurian Biota from Wisconsin (USA)," at the Murchison Symposium; An International Symposium on the Silurian System at Kiele, Great Britain, March 28 - April 8, 1989. During the meeting he also participated in a field trip to the Silurian rocks of Wales and the Welsh borderland.

David L. Moran presented the paper, "Thermogravimetric Characterization of Cyclone and Bottom Ashes from Fluidized-Bed Combustion Studies of Coal-Derived Solid Fuels," at the 17th Annual North American Thermal Analysis Society Conference in Lake Buena Vista, Florida, October 1988.

Samuel V. Panno presented the paper, "Glaciation and Saline-Freshwater Mixing as a Possible Cause of Cave Formation: A Conceptual Model," at the annual meeting of the Geological Society of America in Denver, Colorado, at the end of October 1988.

Robert R. Pool presented the paper, "Developing a Geologic Database for Assessing Mineral Resource Potential of the Paducah Quadrangle," at the GIS Symposium: Integrating Technology and Geoscience Applications sponsored by the National Academy of Sciences in Denver, Colorado, September 1988.

Richard B. Read and Philip J. DeMaris presented the paper, "Advanced Physical Fine Coal Cleaning by ISGS Aggregate Flotation," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988.

J. Bruno Risatti and Joseph FitzPatrick presented the paper, "Microbial Suppression of Pyrite from Illinois Coals: Microbiology, Chemistry, Engineering and Scale Up," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988.

Massoud Rostam-Abadi presented the papers, "Combustion Characteristics of Coal-Derived Solid Fuels," and "Development of High-Surface-Area Hydrated Lime for Sulfur Dioxide Control" at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988. At the 197th meeting of the American Chemical Society, Dr. Rostam-Abadi presented, "Changes in Activation Energy with Level of Burn-off for Bituminous Coal Chars," and "Burning Characteristics of Partially Devolatilized Coals."

Nicholas P. Schneider presented the talk, "Geomorphic Evidence for the Tectonic Segmentation of an Intermontane Basin: Implications for Changing Tectonic History," at the annual meeting of the Geological Society of America in Denver, Colorado, October 31-November 3, 1988. He also participated in a 2-day course on "Glacial Facies Models."

Beverly Seyler presented the paper, "Preliminary Reservoir Characterization of Cypress Sandstone, Parkersburg Field," at the annual meeting of the Eastern Section, American Association of Petroleum Geologists, Charleston, West Virginia, September 1988.

Lisa R. Smith presented the paper, "Regional Site Screening of a Low-Level Radioactive Waste Facility in Illinois," at the annual meeting of the Illinois State Academy of Science, October 1988, in Peoria, Illinois. At the GIS Symposium, "Integrating Technology and Geoscience Applications," held in Denver, Colorado, September 1988, she presented the paper "Siting a Low-Level Radioactive Waste Facility: A GIS Approach." In Palm Springs, California, May 1989, at the Ninth Annual ESRI ARC/INFO Users Conference, Ms. Smith presented the paper, "Using Fundamental ARC/INFO Capabilities to Site a Low-Level Radioactive Waste Facility in Illinois."

Christopher J. Stohr presented the paper, "Remote Sensing Investigations at a Hazardous Waste Landfill," for the Symposium on Engineering Geology Applications of Remote Sensing at the 31st Annual Meeting of the Association of Engineering Geologists in Kansas City, Missouri, October 1988. He also helped to teach the short course, "Introduction to Remote Sensing," at this meeting. At the 55th Annual Meeting of the American Society for Photogrammetry and Remote Sensing in Baltimore, MD., April 2-7, 1989, Mr. Stohr presented the paper, "Reconnaissance of Oil-Brine Pollution Using Two Thermal Infrared Instruments."

Wen-June Su presented the paper, "Determination of True Orientation for Tiltmeters and Its Application to Trench Cover Movement," at the 31st Annual Meeting of the Association of Engineering Geologists in Kansas City, Missouri, October 1988. He also participated in the short, introductory course on remote sensing.

C. Brian Trask presented the paper, "Information System on Illinois Coal: IV. A Combined Database," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988. At the annual meeting of the Geological Society of America in Denver, Colorado, October 31 - November 3, 1988, he presented the paper, "Differentiating a Continuous Sand Body from Isolated Lenses During a Geotechnical Investigation for a Proposed 7-GeV Synchrotron at Argonne National Laboratory, Illinois." At the annual meeting of the North Central Section of Geological Society of America at Notre Dame, Indiana, April 1989, Dr. Trask presented, "Coal Data Available Online at the Illinois Geological Survey."

Colin G. Treworgy presented, "Use of a GIS as a Tool for Geologic Mapping and Analysis," at the GIS Symposium - Integrating Technology and Geoscience Applications in Denver, Colorado, September 1988.

C. Pius Weibel presented, "Diagenetic Features in Transgressive Limestones Suggest Minor Regressions in Upper Pennsylvanian Cyclothems," at the annual meeting of the Geological Society of America in Denver, Colorado, October 31 - November 3, 1988. At the South Central Section meeting in Arlington, Texas, March 1989, he chaired the symposium, "Midcontinent Middle and Upper Pennsylvanian Chronostratigraphy, Biostratigraphy and Paleoecology," and presented the paper, "Status of Inter-Basinal Correlations of Illinois Basin Cyclothems."

Alan D. Williams presented the paper, "Production of Premium Liquids by Mild Gasification," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988. At the 197th meeting of the American Chemical Society in Los Angeles, California, he presented a poster, "The Effect of Oxidation on Desulfurization and Hydrodesulfurization of Illinois Bituminous Coals."

Lawrence Wu presented the paper, "Carbon Monoxide/Ethanol Desulfurization of Illinois High-Sulfur Coal," at the Illinois Coal Development Board Sixth Annual Contractors' Technical Meeting in Urbana, Illinois, August 1988. He also presented an invited talk, "In-Situ Catalytic Removal of Organic Sulfur from Coal," at the Engineering Foundation Conference on Advanced Upgrading of Coal in Santa Barbara, California, January 1989.

Scientific Workshops/Training Courses Attended or Taught

Terri Adams, Robert A. Bauer, David F. Brutcher, B. Brandon Curry, William G. Dixon, Jr., Paul B. DuMontelle, Anne M. Graese, Brenda B. Mehnert, Samuel V. Panno, Vickie L. Poole, Wen-June Su, Robert C. Valden, and Dan J. Van Roosendaal participated in the short course on "Ground Water Pollution and Protection" and attended the meeting of the North Central Section of the Association of Engineering Geologists in Chicago, September 20, 1988.

Daniel J. Adomaitis and Anne M. Graese took a course in groundwater hydrogeology from the Geology Department at the University of Illinois during the fall semester, 1988.

H. Wayne Bang, Mei-In Chou, Chen-Lin Chou, Dennis D. Coleman, B. Brandon Curry, Heinz H. Damberger, Philip J. DeMaris, Joseph A. Devera, Donald R. Dickerson, J. James Eidel, Anne C. Graese, Richard D. Harvey, Paul C. Helgold, Kathleen Henry, Russell J. Jacobson, Dennis R. Kolata, Morris. W. Leighton, Rodney D. Norby, Russell A. Peppers, Michael L. Sargent, Michael S. Summers, Janis D. Treworgy, C. Pius Weibel and two staff of the Indiana Geological Survey attended a 2-day course on "Current Aspects of Basin Analysis and Sedimentary Geology" taught at the University of Illinois, December 15-16, 1988, by George DeVries Klein, professor of geology at the University. Arrangements for the course were made by Dennis Kolata, Head of the Basin and Crustal Analysis Section.

H. Wayne Bang attended a symposium on low-permeability reservoirs sponsored by the Society of Petroleum Engineers and the U.S. Department of Energy in Denver, Colorado, March 1989.

H. Wayne Bang, Robert A. Bauer, Mei-In Chou, Joan E. Crockett, Anne M. Graese, Dennis R. Kolata, Morris W. Leighton, Donald F. Oltz, Rodney R. Ruch, Michael L. Sargent, Paul R. Seaber, Beverly Seyler, Janis D. Treworgy, and Stephen T. Whitaker of the Illinois State Geological Survey and George DeVries Klein, Ralph L. Langenheim, and six graduate students from the University of Illinois attended an audio tape and slide seminar on "Carbonate Platforms and Petroleum Exploration Models." The program was based on a short course taught by Fred Read and sponsored by the American Association of Petroleum Geologists. Dennis Kolata arranged for the short course to be offered at the Survey in October 1988.

Phyllis L. Bannon, Robert A. Bauer, William G. Dixon, Jr., Anne L. Erdmann, Anne M. Graese, David L. Gross, Nicholas P. Schneider, Christopher J. Stohr, Michael S. Summers and Billy A. Trent attended a workshop on "Documenting Historical Hazardous Materials," taught in Springfield, March 1989, by Craig Colton of the Illinois State Museum; Paul Biggers, Randy Schicht, and John Washburn of the Illinois Department of Transportation (IDOT); Lance Perry of the Hazardous Waste Research and Information Center; and Chuck Mikalian and Mike Severns of the Illinois Environmental Protection Agency. Robert A. Bauer and Nick Schneider reviewed the Survey's role in IDOT's environmental property assessment program. The course was arranged for staff of the Illinois State Geological Survey and the Department of Transportation involved in the new environmental property assessment program.

Margaret H. Bargh, James W. Baxter, Joan Crockett, Pamella K. Foster, George D. Graettinger, Donald A. Keefer, John M. Masters, Robert R. Pool, Barbara Stiff, Wen-June Su and Paul Terpstra participated in training in the use of the computer programs GS-MAP, GS-DRAW and GS-MODS. Sponsored by the Illinois State Geological Survey, the course was held in Champaign, September 1988. The instructor, Michael McFarland of the Missouri Geological Survey, volunteered his time.

Robert A. Bauer, Paul B. DuMontelle, and Billy A. Trent organized and participated in an Industry Briefing workshop in August 1988 at Mt. Vernon, Illinois, for the Illinois Mine Subsidence Research Program. At the briefing, Dr. Bauer presented the papers, "Mechanics of Planned and Unplanned Ssubsidence," and "Characterization of Coal Mine Subsidence and Impacts on Bedrock and Near-Surface Hydrology over a Shallow High-Extraction Retreat Mining Operation in Illinois."

Mr. Bauer also attended the 7th International Conference on Ground Control in Mining at Morgantown, West Virginia, August 1988, and participated in a 2-day course on "Dealing with Hazardous Waste on Highway Design and Construction Projects" at the University of Wisconsin-Madison, Madison, Wisconsin, May 1989.

Richard C. Berg, Ross D. Brower, Chen-Lin Chou, Anne M. Graese, Timothy H. Larson, Edward Mehnert, Samuel V. Panno, Vickie L. Poole, Paul R. Seaber, Colin G. Treworgy attended the workshop on Project and Report Planning and Review sponsored by the Illinois State Geological Survey and presented in Champaign, September 1988, by John E. Moore of the U.S. Geological Survey.

Richard C. Berg and Madalene Tierney attended the training session on Quality Assurance/Quality Control taught by Battelle Memorial Institute at Martinsville, Illinois, July 1988. The training session was required for those participating in field studies at the Department of Nuclear Safety's Martinsville Alternative Site for the State's Low-Level Nuciear Waste Disposal Facility.

Subhash B. Bhagwat participated in the program planning conference of the Geoscience Institute in Dallas, Texas, July 1988.

Ross D. Brower attended the training seminar on the Land Ban Petition sponsored by the Region V Office, U.S. EPA in Chicago, June 1988. He also organized technical training sessions related to the processing of water well permits for the Environmental Health Division of the Illinois Department of Public Health. At the Illinois Water Well Association's Midwest Water Well Exposition held in Rockford, Illinois, February 1989, he presented a display on Survey groundwater research and service programs.

Richard A. Cahill presented the seminar, "Radon in Air, Soil and Water--An Illinois Perspective," at the Illinois State Water Survey, May 1989.

Keros Cartwright discussed construction of trench liners and covers for a short course on environmental problems sponsored by the Association of Engineering Geologists, September 1988. He also presented a half-day of lectures on land-fill siting and monitoring for a short course on environmental evaluation at the University of Texas.

Chen-Lin Chou attended the workshop on "Microanalysis of Trace Elements in Coal Using Synchrotron Radiation," September 1988, at Brookhaven National Laboratory, New York, where he presented the lecture, "Geochemistry of Mineral Matter and Trace Elements in Illinois Coal." He also participated in a short course on "Elements of Coal Preparation" at the Pennsylvanian State University, University Park, Pennsylvania, November 1988.

Michael J. Chrzastowski participated in a University of Michigan Sea Grant Program workshop on Great Lakes Coastal Erosion Research Needs, November 1988, and a U.S. Geological Survey/National Oceanic and Atmospheric Administration-sponsored workshop for a proposed Great Lakes Mapping Program in March 1989, both held at Ann Arbor, Michigan. In January 1989 he reviewed the use of sidescan sonar in surveying the Lake Michigan shore defense structures for the Symposium on Remote Sensing and Its Applications sponsored by the Illinois Mapping Advisory Committee at Champaign. Also in January 1989, he and **Charles Collinson, Ardith K. Hansel, and James R. Jennings** made brief presentations on the status of the Survey's Lake Michigan research projects and participated in planning discussions at a workshop on the Southern Lake Michigan Coastal Erosion Study sponsored by the U.S. Geological Survey at their Center for Coastal Geology, St. Petersburg, Florida. **Matthew Riggs** also attended the workshop.

Joan E. Crockett coordinated a 1-day workshop on applications of coring in petroleum exploration and development entitled "Practical Log Interpretation in the Illinois Basin." Sponsored by the Illinois Geological Society and taught by Jeff Hoy, the workshop was held in Mt. Vernon, Illinois, May 1989. Other Survey staff who participated in the workshop included **R. Todd Black, Donald F. Oltz, and C. Plus Welbel.**

Joan E. Crockett, Joseph A. Devera, Wayne T. Frankie, Anne M. Graese, Paul C. Helgold, Richard H. Howard, Bryan G. Huff, Dennis R. Kolata, Timothy H. Larson, W. John Nelson, Donald F. Oltz, Vickie L. Poole, Michael L. Sargent, Beverly Seyler, Janis D. Treworgy, and Stephen T. Whitaker of the Illinois State Geological Survey and Steven Altaner of the University of Illinois Geology Department, Brandon Nuttall of the Kentucky Geological Survey, and David Mackey of the U.S. Geological Survey all participated in a 4-day workshop on Petroleum Exploration with Integrated Seismic Sequence Stratigraphy and Facies Models, June 1989. Sponsored by the Survey and held in the Survey's conference room, the course was taught by Robert Mitchum, a consulting geologist.

B. Brandon Curry participated in quality assurance/quality control training for the low-level nuclear waste disposal facility siting project taught by Battelle Memorial Institute staff at Fairfield, Illinois, August 1988.

Donald R. Dickerson attended the seminar on "Hyphenated Instrument Techniques" sponsored by Hewlett-Packard Instrument Company at Urbana, September 8, 1988 and the symposium on "Solving Problems in Environmental Analysis" sponsored by Perkin-Elmer Corporation in St. Louis, Missouri, December 1988.

Gary B. Dreher took Soils 101-Introduction to Soils and Soils 307-Soil Chemistry in the Agronomy Department at the University of Illinois.

Henry P. Ehrlinger III attended a 1-day class, "Effective Writing," in Springfield.

J. James Eidel represented the Society of Exploration Geologists at a workshop sponsored by the American Geological Institute in Madison, Wisconsin, September 1988, to provide information needed to begin the process of developing a new earth science curriculum for kindergarten through grade 12. He also took a course on Handling Problem Employees taught by Padgett and Thompson, Inc.

Anne L. Erdmann was among those who took instruction in the use of the ARC/INFO software system at the Illinois State Geological Survey, December 1988. The workshop was taught by staff members of the Computer Research and Services Section. She later taught ARC/INFO for Users of the Hazardous Waste Research and Information Center database for five other Survey staff in the Environmental Studies and Assessment Unit.

Robert R. Frost participated in 2 days of workshops on X-ray fluorescence quantitative analysis and sample preparation techniques during the 37th Annual Denver X-Ray Conference held in Steamboat Springs, Colorado, August 1988.

Anne M. Graese participated in a 2-day course on Geological Considerations in Hazardous Waste Site Characterization, October 1988 in Denver, Colorado, sponsored by the Geological Society of America.

George D. Graettinger, Robert J. Krumm, E. Donald McKay III, Lisa R. Smith, Gail D. Taylor, and Colin G. Treworgy participated in workshops on "Mapping Geologic Surfaces" and "Data Analysis and Modeling in GIS Environments" while attending the GIS Symposium: Integrating Technology and Geoscience Applications in Denver, Colorado, September 1988.

Ardith K. Hansel participated in the workshop to develop a study plan for Great Lakes studies sponsored by the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, March 1989, in Ann Arbor, Michigan.

Beverly L. Herzog attended the annual meeting of the National Water Well Association in Las Vegas, Nevada, December 1988, where she participated in a panel discussion on "Key elements of a good review" for the workshop on "What constitutes a good review." She also participated in the workshop on "Skills needed for expert witness testimony." During the early spring, Ms. Herzog attended three short courses on the Statistical Analysis System (SAS) software package taught at the University of Illinois.

Bryan G. Huff, Alison B. Lecouris and Donald F. Oltz received 4 days of training in early May in the use of the ZYCOR programs Z-MAP, B-MAP, EML and STRATVIEW resident on the Survey's new VAX computer purchased for the improved oil recovery project.

Latif A. Khan participated in a short course, "Aggregate Mine Operation, Mitigation and Concurrent Reclamation Planning," in Las Vegas, Nevada, December 7, 1988.

Dennis R. Kolata and Michael L. Sargent participated in a core workshop and symposium on the Lower Paleozoic rocks of the Michigan Basin at Western Michigan University, Kalamazoo, MI., December 7-9, 1988.

Carl W. Kruse participated in the Coal Opportunities Workshop sponsored by the U.S. Department of Energy, Washington, DC., July 12, 1988.

Timothy H. Larson took an intensive summer course in conversational French in the College of Agriculture, University of Illinois, June 23-July 28, 1988 in preparation for his trip to a scientific conference in France.

Dennis P. McKenna discussed the paper "What are we trying to protect?" at the workshop for state personnel on Pesticides in Groundwater sponsored by the Region V office of U.S. EPA in Rosemont, Illinois, November 29-30, 1988. **Edward Mehnert** also participated in this workshop.

Edward Mehnert participated in a 12-hour workshop on survey research methods taught by the University of Illinois Survey Research Laboratory, July 5-21, 1988 in Champaign.

Duane M. Moore participated in a workshop on "Magnetic resonance methods in clay science" on September 17, 1989 just before the annual meeting of the Clay Minerals Society in Grand Rapids, Michigan. In Denver, October 29-30, 1989, he participated in the workshop on "Hydrous Phyllosilicates (Exclusive of Micas)," sponsored by the Mineralogical Society of America.

Mary J. Mushrush participated in six short courses taught by the University of Illinois Computer Services Office.

Donald F. Oltz participated in a workshop on Paleohydrology of Sedimentary Basins taught by Craig Bethke at the University of Illinois at Urbana-Champaign, May 2-4,1989.

Samuel V. Panno took four short courses on computerized statistical analysis from the Computer Services Office, University of Illinois. He also participated in a 5-day course on "Statistical Analysis of Hydrologic and Chemical Data" at the U.S. Geological Survey's training center in Denver, Colorado, April 24-28, 1989.

Jim C. Ploetz took courses in "DOS for Microcomputers" and "Accounting and Bookkeeping" at Parkland College and a short-course on "D-Base III Plus" at the University of Illinois Computer Services Office.

Robert R. Pool taught an ARC/INFO training class on "Using INTERACTIVE ARCPLOT" for several Survey staff members.

Vickie L. Poole participated in a short course on "Advanced Geophysical Log Analysis and Formation Evaluation" at the U.S. Geological Survey Training Center in Denver, Colorado, February 6-10, 1989.

Philip C. Reed participated in the short course, "Theory and Application of Surface Geophysics to Ground Water Investigations," offered by the National Water Well Association, March 7-8, 1989. He also participated in training by the CPN Corporation on May 25, 1989, to satisfy mandatory safety requirements for use of portable nuclear testing devices.

J. Bruno Risatti presented an invited lecture on "Dechlorination of Polychlorinated Biphenyls by Anaerobic Bacteria" at the Workshop on Degradative Technologies for Treating Chemical Wastes at San Miniato, Italy, June 26-29, 1989.

Nicholas P. Schneider participated in a short course on "Geotechnical Aspects of Groundwater Contamination, Clean-up and Waste Containment" presented by the Geological Engineering Foundation at Tahoe City, California, June 11-16, 1989.

Beverly Seyler was trained in "Microbeam Analysis With the Scanning Electron Microscope" by Tracor Northern Instruments, Inc., July 10-15, 1988.

Edward C. Smith took a class in Fluvial Geomorphology in the fall of 1988. He and **Christopher J. Stohr** took a Special Topics seminar on Quaternary Geology at the University of Illinois during the spring semester.

Christopher J. Stohr and David L. Reinertsen met with seven teachers from the Urbana and Champaign school districts in May 1989 to discuss the use of satellite imagery in earth science instruction.

Wen-June Su received training from Troxler Electronic Laboratory, Inc., Elgin, Illinois, in the use of nuclear testing equipment. He also took four short courses in "Asyst" programming at the University of Rochester, Rochester, New York, October 9-11, 1988. At the Construction Engineering Research Laboratory in Champaign, January 20, 1989, he participated in a workshop on the personal computer version of the Fujitsu ELM finite element program. On February 14, 1989, in Springfield, Illinois, he participated in a workshop on the ORACLE database management system and CASE.

Michael S. Summers participated in a short course on "Industrial Practice of Fine Coal Processing" sponsored by the Society of Mining Engineers at Somerset, Pennsylvania, September 15-16, 1988.

Gail D. Taylor took classes at the University of Illinois on "Earth's Physical Systems," "Regional Analysis of Landforms," "Introduction to Forestry," and "Regional Geology Field Study." This latter course included an extended field trip to the southern Rocky Mountains, Colorado Plateau, and central Basin and Range Provinces. For a University of Illinois Cartography class, Ms. Taylor demonstrated the capabilities of the GIS system.

Paul D. Terpstra took a course in coastal geomorphology in the University of Illinois Geography Department. The course included a field trip to the Lake Michigan coast line in Wilmette, Chicago and Indiana Dunes.

C. Brian Trask and Robert C. Valden took "Introduction to Groundwater Hydrology" in the geology department of the University of Illinois during the fall of 1988. Mr. Trask also took a correspondence course in Associate Logistics Executive Development from the U.S. Army Logistics Management College, Fort Lee, Virginia. At the Central States Education Center in Champaign, he attended a 1-day course on "Cutting Waste Volume: Making Source Reduction and Recycling a Top Priority."

Billy A. Trent took classes in English during the fall and spring semesters, continuing her progress toward an undergraduate degree in that subject.

John R. Valkenburg took classes in mathematics and civil and mechanical engineering during the fall and spring semesters at the University of Illinois at Urbana-Champaign.

Participation in Scientific Conferences and Field Trips

Terri Adams, William G. Dixon, Jr., Edward Mehnert, Phil Orozco, Samuel V. Panno, Vickie L. Poole, and Cheryl Wegscheid attended the October 19, 1988 meeting in Naperville, Illinois, and the March 16, 1989, meeting in St. Charles, Illinois, of the Illinois Groundwater Association. At the fall meeting, Mr. Panno spoke on "Glaciation and Saline-Freshwater Mixing as a Possible Cause of Cave Formation: A Conceptual Model." At the meeting in St. Charles, Illinois, they participated in a field trip to the Settler's Hill landfill and methane gas recovery plant.

Daniel J. Adomaitis, Wen-Teh Chen, Chen-Lin Chou, Mei-In Chou, Joseph A. DeBarr, Philip J. DeMaris, Ilham Demir, Keith C. Hackley, David L. Moran, David M. Rapp, William R. Roy, Richard H. Shiley, and Michael S. Summers attended the Sixth Annual Illinois Coal Development Board Contractors' Technical Meeting, organized by the Center for Research on Sulfur in Coal and held in Urbana, August 2-4, 1988.

Robert A. Bauer reviewed the geological and geotechnical investigations for the SSC in Illinois for a combined meeting of the North Central Section of the Association of Engineering Geologists and the Chicago Section of the Society of Mining Engineers on October 25, 1988, for the Illinois-Indiana Section of the American Institute of Professional Geologists in Aurora on November 15, 1988, and for the University of Illinois Geology Department Colloquium on February 3, 1989.

James W. Baxter, Subhash B. Bhagwat, and Latif A. Khan attended the 1988 Symposium on Surface Mining, Hydrology, Sedimentology and Reclamation in Reno, Nevada, December 4-8, 1988. Dr. Baxter presented the talk "Recovery of coal from the effluent of two operating mines;" Dr. Bhagwat presented "Economics and environmental costs/benefits of secondary fine coal recovery--an Illinois case study" and Dr. Khan presented "Froth Flotation of Coal Fines from Illinois Coal Mine Effluent." At the Symposium on Midcontinent Mineral Resource Potential (the "Mini-McKelvey Forum") held in St. Louis, April 11-12, 1989, Dr. Baxter presented a poster display on the "Present status of the Paducah CUSMAP project" and Dr. Bhagwat discussed "Strategic and Critical Minerals--What Are They? Who Needs Them?"

James W. Baxter and J. James Eidel represented the Illinois State Geological Survey at the planning session for the Mid-Continent Strategic and Critical Minerals Program held in Estes Park, Colorado, on November 13-17, 1988, and the Paducah CUSMAP planning meeting at Cape Girardeau, Missouri, June 27-28, 1989. During the course of the Estes Park meeting there was also a one-day meeting in Denver on the Paducah CUSMAP project where Eidel represented the Survey in the Hicks Dome and Mississippi Valley-type Ore Deposit panel discussions. In connection with the Cape Girardeau meeting they participated in a field trip to review stratigraphic terminology in Missouri. They also attended the annual meeting of the Society of Mining Engineers (SME) of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), February 26 - March 3, 1989, in Las Vegas, Nevada.

Subhash B. Bhagwat attended the annual Mineral Economics Symposium sponsored by the Society of Mining Engineers (SME) in Washington, D.C., Nov. 16-17, 1988, and the MRMC Symposium on Excess Capacity in World Metal Mining held at Las Vegas, February 26-March 2, 1989, in conjunction with the annual meeting of SME-American Institute of Mining, Metallurgical and Petroleum Engineers.

Ross D. Brower attended the Midwest Groundwater Conference in Columbus, Ohio, October 11-13, 1988, and the Illinois Groundwater Association meeting in Lisle, Illinois, October 19, 1988.

David F. Brutcher, Brenda B. Mehnert, and Dan J. Van Roosendaal attended the 30th U.S. Symposium on Rock Mechanics, June 19-22, 1989, in Morgantown, West Virgina, and visited the U.S. Department of Energy Research Center in Pittsburgh, Pennsylvania, during the meeting. They also attended the 10th Annual Conference of the Indiana Water Resources Association, June 7-9, 1989, in Vincennes where Mr. Brutcher presented the paper "Hydrologic Response to Longwall Mining in Illinois."

Richard A. Cahill attended the Symposium on Radon and Radon Reduction Technology sponsored by the U.S. EPA, October 17-21, 1988 in Denver, and the spring meeting of the American Geophysical Union in Baltimore, May 7-12, 1989. At the meeting on Gas Quality and Energy Measurements sponsored by the Institute of Gas Technology in Chicago, June 12-13, 1989, he presented the paper "An Overview of the Significance of Radon in Natural Gas."

Keros Cartwright presented the lecture titled "Large-Scale Experiments in Hydrogeology" at the 10th annual meeting of the Indiana Water Resources Association in Vincennes, June 9, 1989.

Chen-Lin Chou attended the annual meeting of the Geological Society of America in Denver, October 31 - November 3, 1988, and a pre-meeting field trip on "An Integrated View of Depositional Systems of the Early Tertiary Coal Measures, Powder River Basin, Montana and Wyoming. Others who attended the GSA meeting included **Dennis D. Coleman, Leon R. Follmer, Jonathan H. Goodwin, Anne M. Graese, David L. Gross, Keith C. Hackley, Ardith K. Hansel, Richard D. Harvey, Russell J. Jacobson, Myrna M. Killey, Morris W. Leighton, Chao-Li Liu, J. Bruno Risatti, and Michael L. Sargent**.

Joan E. Crockett, Joyce K. Frost, Anne M. Graese, and Duane M. Moore attended "New Perspectives on the Paleozoic History of the Upper Mississippi Valley: An Examination of the Plum River Fault Zone," the 18th annual field trip of the Great Lakes Section of the Society of Economic Paleontologists and Mineralogists, October 1-2, 1988.

Steven J. Chillson, Anne M. Graese and Robert C. Valden attended the meeting of the Illinois Groundwater Association at St. Charles, March 16, 1989, and participated in the field trip to Waste Management, Inc.'s Settler's Hill landfill and methane gas recovery plant.

Dennis D. Coleman chaired the session on "Gas Quality: Problems, Analysis and Treatment" at the Symposium on Gas Quality and Energy Measurement sponsored by the Institute of Gas Technology in Chicago, June 12-13, 1989.

Heinz H. Damberger attended the annual meeting of the Illinois Mining Institute at Mt. Vernon, Illinois, September 29-30, 1988. At the meeting **Robert A. Bauer and Paul B. DuMontelle** presented a poster display on the current status of the Mine Subsidence Research Program. Other Survey staff members who participated in the meeting included **Chen-Lin Chou, Richard D. Harvey, and C. Brian Trask**.

William S. Dey attended the regional meeting of the Soil and Water Conservation Society held in Springfield, September 21, 1988, where water quality issues were reviewed. He also attended the International Symposium on Modelling Agricultural, Forest and Rangeland Hydrology, held December 12-13, 1988 in Chicago.

William G. Dixon, Jr., and Paul B. DuMontelle attended the annual meeting of the Association of Engineering Geologists, October 16-20, 1988, in Kansas City, Missouri. At the meeting, Mr. Dixon participated in the field trip on Geology and Utilization of Underground Space.

Gary B. Dreher attended the 1989 conference on Hazardous Wastes and Hazardous Materials in New Orleans, April 12-14, 1989.

Paul B. DuMontelle attended the annual meeting of the Illinois-Indiana Section of the American Institute of Professional Geologists at Aurora, Illinois, November 15, 1988, and the regular monthly meetings of the North Central Section of the Association of Engineering Geologists in Chicago. Others who attend the North Central Section meetings included **Robert A. Bauer, William G. Dixon, Jr., Myrna M. Killey, Brenda B. Mehnert, Nicholas P. Schneider, Christopher J. Stohr, and C. Brian Trask.**

Henry P. Ehrlinger III attended the annual meeting of the Society of Mining Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers in Las Vegas, February 26 - March 2, 1989. In conjunction with that meeting he also attended the Accreditation Board for Engineering and Technology workshop.

J. James Eidel and Michael L. Sargent participated in field trips on the stratigraphy and sulfide mineralization of the Bonneterre Dolomite and related Cambrian and Precambrian rocks in the Old Lead Belt region of southeast Missouri, December 4-5, 1988, with Ernest Ohle, a consulting geologist, and geologists from the U.S. and Missouri Geological Surveys. On December 6, they visited the Pea Ridge Iron Mine, regarded as an Olympic Dam-type ore deposit analog, with the midcontinent mineral resource potential working group. Eidel also visited Hicks Dome with Joe Porter and Jim Bradbury, Emeritus Principal Geologist of the Illinois State Geological Survey.

Leon R. Follmer chaired a technical session and participated as a poster judge at the International Working Meeting on Soil Micromorphology, San Antonio, Texas, July 10-15, 1988. He also co-hosted a tour from Wisconsin through Illinois to Indiana for the Soil Micromorphology Conference, July 5-8, 1988. From September 13 to 15, 1988, he attended the meetings of the German Quaternary Association in Wurzburg, Germany. He then worked with a German colleague surveying the provenance of soils in northern Italy from September 18-23. From September 26 to October 1, he attended meetings of the Loess Commission of the International Quaternary Association in Verona, Italy, where he led a discussion session on Mississippi Valley loess and participated in field trips examining loess deposits in northern Italy. Dr. Follmer was a co-leader of a field trip to the Lompoc, California, area, December 2-4, 1988 following the annual meeting of the Soil Science Society of America meeting in Anaheim, California, November 27 - December 1. On December 10, he hosted a meeting of the Illinois Quaternary Association in Champaign and he attended the annual meeting of the Illinois Soil Classifiers Association in Bloomington on March 18, 1989.

Wayne T. Frankie attended the meeting of the Midwest Coal Section of the Society of Mining Engineers-AIME monthly meeting in Marion, Illinois, February 16, 1989, the combined meeting of the Illinois Geological Society and the Society of Petroleum Engineers in Marion on February 28, 1989, and the annual meeting of the Illinois Oil and Gas Association in Mt. Vernon on March 2-3, 1989.

Anne M. Graese, Brenda B. Mehnert, Edward Mehnert, and Christopher J. Stohr attended a meeting of the North Central Section of the Association of Engineering Geologists in Milwaukee, Wisconsin, March 21, 1989: "Groundwater Aspects of the Design and Construction of the Milwaukee Deep Tunnels." During the meeting they visited the deep tunnels being constructed to handle storm drainage in the Milwaukee area. Ms. Mehnert also attended the AEG meeting in Chicago on February 28, 1989, on the topic of compressed air energy storage in the midwest. On December 9, 1988, Ms. Graese participated in a meeting of the Illinois-Indiana Section of the American Institute of Professional Geologists held at Batavia, Illinois.

Robert A. Griffin and William R. Roy attended meetings of the Environmental Institute for Waste Management Studies in Tuscaloosa, Alabama, July 28-29, 1988, and January 26-27, 1989.

Ardith K. Hansel and John P. Kempton attended the meeting of the North Central Section of the Geological Society of America at Notre Dame, Indiana, April 20-21, 1989. They also participated in a pre-meeting field trip on glacial terrain models in north-central Indiana: vertical sequences derived from downhole geophysics linked to landscapes and near-surface stratigraphy. Dr. Hansel also attended the 36th Field Conference of the Midwest Friends of the Pleistocene, May 12-14, 1989, in Watertown, South Dakota.

Richard D. Harvey presented an exhibit and demonstration, "Coal Information Systems at the Illinois State Geological Survey," during the annual meeting of the Illinois Mining Institute, September 29-30, 1988, in Mt. Vernon, Illinois. He also participated in a presentation on the History of the Coal Division of the Geological Society of America at the annual meeting in Denver, October 31 to November 3, 1988. At the Illinois Coal Development Board's 6th Annual Contractors' Technical Meeting in Urbana, August 2-4, 1988 he shared the podium with **C. Brian Trask** to present their research project entitled "Information System on Illinois Coal IV: A Combined Database." Dr. Harvey also participated in the fall meeting of the Committee on Coal and Coke (D-5) of the American Society for Testing and Materials in Toronto, Canada, October 9-12, 1988. He also attended the fall meeting of the Illinois Society of Coal Preparation Engineers and Chemists in Benton, Illinois, November 16, 1988. During the spring, Dr. Harvey attended meetings of the local PC user's group at the University of Illinois on February 15 and March 15, 1989.

Paul C. Heigold and Vickie L. Poole attended the spring meeting of the American Geophysical Union in Baltimore, May 7-12, 1989.

Beverly L. Herzog and Vickie L. Poole participated in a U.S. EPA seminar on Requirements for Hazardous Waste Landfill Design, Construction and Closure held in Chicago, July 14-15, 1988. They also attended the meeting of the Illinois Groundwater Association in St. Charles, Illinois, March 16, 1989, and participated in a field trip to Waste Management, Inc.'s chemical laboratory and sanitary landfill.

Carol A. Hindman attended the Ninth Annual ARC/INFO User Conference sponsored by Environmental Systems Research Institute at Palm Springs, California, May 22-24, 1989.

Bryan G. Huff attended meetings of the Illinois Geological Society in Olney, October 19, and in Grayville, December 14, 1988. He also attended the annual meeting of the Illinois Oil and Gas Association in Mt. Vernon, March 2-3, 1989.

Donald A. Keefer participated in the symposium "Geographic Information Systems - Integrating Technology and Geoscience Applications" sponsored by the National Academy of Sciences in Denver, September 26-30, 1988. He also attended the Eleventh Annual Madison Waste Conference in Madison, September 13-14, 1988.

Latif A. Khan attended the annual meeting of the Society of Mining Engineers (SME) of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) in Las Vegas, February 29 - March 3, 1989.

Myrna M. Killey and C. Brian Trask jointly presented the talk "Geotechnical Site Investigation for a 7-GeV Synchrotron at Argonne National Laboratory" at the fall meeting of the Illinois-Indiana Section of the American Institute of Professional Geologists in Aurora, Illinois, December 9, 1988. They discussed hydrogeological conditions of the Advanced Photon Source at Argonne National Laboratory for the Environmental Pathway and Remedial Analysis Section, Environmental Assessments and Information Sciences Division, Argonne National Laboratory, on June 29, 1989. As the new president of the Illinois-Indiana Section, Ms. Killey participated in the spring meeting of the section at Vincennes, IN., May 5, 1989.

Dennis R. Kolata prepared a paper and discussed the geology at stops in northwestern Illinois for the SEPM Great Lakes Section 18th Annual Field Conference, "New Perspectives on the Paleozoic History of the Upper Mississippi Valley: An Examination of the Plum River Fault Zone," October 1-2, 1988. He also presented lectures on the tectonic history of the Illinois Basin to the Illinois Geological Society in Olney, Illinois, October 19, 1988, the Indiana and Kentucky Geological Society in Evansville, Indiana, February 16, and the Midcontinent Strategic and Critical Minerals Symposium (the "Mini-McKelvey Forum) in St. Louis, April 11, 1989.

Robert J. Krumm and Gail D. Taylor presented a talk and video on "Geographic Information Systems: A Tool for Environmental Analysis and Siting Studies" for a meeting of the Illinois Association of Environmental Professionals at the State of Illinois Center, Chicago, July 26, 1988. At the annual meeting of the National Association of State Land Reclamationists, September 21, 1988, In La Salle, Illinois, Mr. Krumm discussed "Geographic Information Systems - Applications for Mine Permit Review in Illinois." He presented a talk entitled "The Geographic Information System: A Mapping System for All of Illinois" to meetings of both the Illinois Association of County Zoning Officials and the Illinois Association of County Board Members and County Commissioners in Springfield, on April 25, 1989. During the year, he also attended the Wisconsin-Illinois GIS Users Group Meeting at Northern Illinois University, De Kalb, Illinois, August, 8, 1988, and the Great Lakes/Midwest Section, ARC/INFO Users Group sponsored by the Minnesota Land Management Information Center, October 4-5, 1988 in St. Paul, Minnesota.

M. W. Leighton served as panel chair at the GIS Symposium, "Integrating Technology and Geoscience Applications," sponsored by the National Academy of Sciences, the U.S. Geological Survey, and the Association of American State Geologists. He participated in annual meetings of the Water Resources Center, Unversity of Illinois, as a member of its Executive Committee and of the Association for Research on Sulfur in Coal as a board member. He also attended meetings of the Geoscience Institute for Oil and Gas Recovery where he served as a board member.

John M. Masters attended the 25th Forum on the Geology of Industrial Minerals in Portland, Oregon, April 30 - May 6, 1989. Field trips during the meeting included visits to sand and gravel, cement and "sugar rock," zeolite, bentonite, diatomite, pumice and scoria mines and processing plants. Mr. Masters attended the 36th annual field conference of the Midwest Friends of the Pleistocene in Watertown, South Dakota, May 12-14, 1989 and the spring meeting of the Illinois Quaternary Association at the Illinois State Museum in Springfield, June 24, 1989.

Dennis P. McKenna attended the symposium on Agrichemicals and Groundwater Protection sponsored by the Freshwater Foundation in St. Paul, Minnesota, October 24-25, 1988. At the Annual Conference on Water Quality and Management sponsored by the University of Illinois Cooperative Extension Service, November 15-16, 1988 at Champaign, Mr. McKenna spoke on "Agricultural Chemicals in Rural Private Wells in Illinois: Recommendations for a Statewide Survey." He presented the same address at the Public Policy Forum sponsored by the Governor's Advisory Council on Groundwater Protection in Naperville, Illinois, December 1, 1988.

Edward Mehnert attended the Third Annual Outdoor Action Conference on Aquifer Restoration, Ground Water Monitoring and Geophysical Methods in Orlando, Florida, May 22-25, 1989, where he presented the paper, "Design of a Sampling System for Agricultural Chemicals in Rural, Private Water-Supply Wells." He also attended the Annual Conference on Water Quality and Management sponsored by the University of Illinois Cooperative Extension Service, November 15-16, 1988, at Champaign.

Donald G. Mikulic and Nicholas P. Schneider participated in the 52nd Annual Tri-State Geological Field Conference, "The La Salle Anticline and Its Influence on Pennsylvanian Sedimentation in the La Salle-Peru Area," October 14-16, 1988 in La Salle, Illinois. Dr. Mikulic also led a field trip to the Thornton Quarry near Chicago for the Illinois Science Teachers Association Annual Meeting, September 30, 1988.

Michael V. Miller attended the 36th annual field conference of the Midwest Friends of the Pleistocene in Watertown, South Dakota, May 12-14, 1989.

David L. Moran attended the First Combined Flue Gas Desulfurization and Dry SO_2 Control Symposium in St. Louis, Missouri, October 25-29, 1989.

Donald F. Oltz presented the talk, "Reservoir Characterization in Illinois: A Program for the Independent Operators," at the meeting of the Independent Oil Producers Association in Evansville, Indiana, June 19, 1989. In San Antonio, Texas, April 22-27, 1989, he attended the annual meeting of the American Association of Petroleum Geologists. He also attends the monthly meetings of the Illinois Geological Society.

Robert R. Pool attended the meeting of the National Association of State Land Reclamationists at La Salle, September 21, 1988. At the meeting of the Advisory Committee for the Computerized River Information Center held in Champaign, March 23, 1989, Mr. Pool reviewed the project to build the geological databases for the Paducah CUSMAP. At the June meeting of the Illinois Mapping Advisory Committee in Champaign, he discussed the digitizing of soil map sheets for Champaign County.

Vickie L. Poole, Matthew Riggs, Michael L. Sargent, and Edward C. Smith attended the annual meeting of the North Central Section, Geological Society of America in Notre Dame, Indiana, April 20-21, 1989. Mr. Sargent was also one of the leaders of a field trip on "Recent interpretations of the stratigraphy and geology of the Kentland Structure, Kentland, Indiana," on April 19.

Philip C. Reed, Vickie L. Poole, Edward Mehnert, and Ross D. Brower presented a poster exhibit on deep well disposal and mapping of underground sources of drinking water at the Illinois Water Well Association Exposition meeting in Rockford, Illinois, February 27-28, 1989, and at the National Water Well Association Upper Midwest Water Well Exposition, April 5-7, 1989, at LaCrosse, Wisconsin.

Matthew Riggs attended the fall meeting of the Illinois Quaternary Association in Champaign, October 10, 1988.

Nicholas P. Schneider organized and presented a program on the SSC technical data for the North Central Section of the Association of Engineering Geologists, January 17, 1989, in Chicago.

Paul R. Seaber presented a talk on hydrologic influences on Florida's phosphate industry, mining and waste disposal operations for the North Central Section of the Association of Engineering Geologists, February 23, 1989. He also made presentations at the meetings of the Illinois Groundwater Association in Naperville and St. Charles.

Beverly Seyler attends the regular monthly meetings of the Illinois Geological Society. At the meeting in Olney. IL. in January, she presented a talk on "Analysis of a Cypress Sandstone reservoir, Parkersburg Field." She also attended the annual meeting of the Illinois Oil and Gas Association, Mt. Vernon, IL., March 3-5, 1989.

Richard H. Shiley and Lawrence Wu attended the meeting on "Opportunities in the Synfuels Industry" at Bismarck, N.D., August 28-31, 1988 and participated in a tour of the Great Plains Coal Gasification facility and the Antelope Valley power station and on-site lignite mine at Beulah, ND. Mr. Shiley presented the talk "Carbon monoxide-ethanol desulfurization of Illinois high-sulfur coal" for the Illinois Corn Marketing Board Annual Contractors' Technical Meeting in Champaign, IL., March 28, 1989 and both he and Mr. Wu responded to questions following the talk.

Christopher J. Stohr participated in the annual field trip of the North Central Section of the Association of Engineering Geologists, April 26, 1989 on Stratigraphy and engineering geology of glacial deposits in the Chicago area. He also attended the Western Great Lakes Regional Meeting of the American Society of Photogrammetry and Remote Sensing.

Robert C. Valden presented a talk on the hydrogeology of the SSC study area for the fall meeting of the American Institute for Professional Geologists at Aurora, Illinois, December 1989.

Cheryl Wegscheid and Cheri A. Chenoweth presented the poster, "Cross Sections, Sand/Gravel Drift Thickness and Bedrock Topography Maps from WELLBASE and Autocad," at the 1989 Computer Fair at the University of Illinois.

C. Pius Weibel was a co-leader with Ralph L. Langenheim, Jr. of the field trip, "From the Basin and Range to the Edge of the Plains--In the Tracks of Wheeler, Powell, and Hayden," October 26-29, 1989, in conjunction with the annual meeting of the Geological Society of America. At the meeting of the South Central Section in Texas in March, 1989, Dr. Weibel participated in the field trip "Middle and Late Pennsylvanian chronostratigraphic boundaries in north-central Texas.

Stephen T. Whitaker presented the talk, "Hydrocarbon Accumulation in a Paleovalley at the Mississippian-Pennsylvanian Unconformity: Implications for Future Exploration in Illinois," at the spring meeting of the Illinois-Indiana Section, American Institute of Professional Geologists, May 5, 1989.

Alan D. Williams participated in the Conference on Mild Gasification at Morgantown, West Virginia, July 19, 1989.

Lawrence Wu participated in the Fifth Annual International Pittsburgh Coal Conference in Pittsburgh, Pennsylvania, September 12-16, 1988.

John D. Yeko attended the ORACLE International Users Conference in Orlando, Florida, October 2-6, 1988.

Lectures/Classes/Seminars Taught

James W. Baxter presented an illustrated lecture, "Minerals of Illinois," to the University Agronomy Clubs of Region 4 meeting at the University of Illinois, April 1, 1989.

Richard C. Berg presented a lecture, "Waste Siting Issues in Illinois," for an Environmental Sciences class at the University and provided research advice to graduate student Mary E. Holden. He also discussed environmental geology for the 4th grade class at Yankee Ridge Elementary School, Urbana.

Dwain J. Berggren presented the illustrated lecture, "The Origin of the Earth and the Resources of Champaign County," to two geography classes at University High School, October 13, 1988.

Subhash B. Bhagwat taught Mineral Economics 302, an advanced level course in mineral economics for the Materials Science and Engineering Department, University of Illinois during the fall semester 1988.

Keros Cartwright presented the lecture, "Large-Scale Experiments in Hydrogeology," for a Purdue University seminar, October 6, 1988. He also served as a thesis advisor for Douglas Kelley, M.S. candidate, University of Illinois, and for Lomboc Hutasoil and Peter Vagt, Ph.D. candidates at Northern Illinois University.

Michael J. Chrzastowski led a 1-day field trip on October 9, 1988, along the Chicago lakefront for the University of Illinois Geography Department's class in coastal geomorphology. He also presented seminars on his previous research on the coastal geology of Delaware and the ongoing Lake Michigan program at the Geology Departments of Indiana University on April 17 and the University of Illinois - Chicago on May 18, 1989. He also provided reference materials and research ideas for several students in the University of Illinois' coastal geomorphology class and technical advice for graduate students from Southern Illinois University-Carbondale and University of Wisconsin-Madison doing field projects involving vibracoring.

Dennis D. Coleman lectured on radiocarbon dating for a class in the Ancient Technologies and Materials program at the University of Illinois. He is also serving as a member of Linda Bonnell's Ph.D. advisory committee. Ms. Bonnell is studying reduced sulfur in Cretaceous organic-rich shales at the Geology Department, University of Illinois at Urbana-Champaign.

Charles Collinson and James R. Jennings gave talks on the general characteristics of the Lake Michigan shoreline, instructional opportunities offered by the shore, and ISGS support services and facilities for earth science teaching at a quarterly meeting of the Illinois Earth Science Teachers Association in Lake Forest, April 21, 1989. They also led the teachers on a field trip to the Forest Park marina and recreation park development. Dr. Collinson is also a thesis advisor for "The Lake Michigan Icefoot Complex--Conditions of Formation and Destruction: An Evaluation of Winter Erosion at Wilmette, Illinois," a study by James Minor, candidate for the Master of Science degree in geology from Northern Illinois University.

Joan E. Crockett provided informal technical assistance to Mark Winterheimer, a graduate student at Southern Illinois University at Carbondale studying the Salem Limestone in the Illinois Basin, and to Jerilyn Gilmore, a graduate student at Southern Illinois University at Edwardsville studying the possibility that bedrock fracture systems control present drainage locations and hydrocarbon reservoir locations.

B. Brandon Curry lectured on principles of electron spin resonance age dating for a class in Quaternary Geology at the Geology Department, University of Illinois. He has also assisted graduate students from Northern Illinois University, Western Illinois University and the University of Kansas with various aspects of Illinois geology.

Joseph A. Devera presented a talk on dinosaurs to several grade school classes and a troop of boy scouts in the Carbondale area. He also spoke on ichnofossils for a graduate seminar in the geology department at SIU-Carbondale.

Philip J. DeMaris presented a lecture on coal geology for a short course sponsored by the Energy Education Association and held at Rend Lake Community College, Ina, Illinois, on August 9, 1988. He also spoke about geology to a Webelos den of cub scouts on April 17, 1989.

Paul B. DuMontelle is a member of the graduate advisory committee of Mr. Wen-June Su, a candidate for the Ph.D. in Engineering Geology from the University of Illinois at Urbana-Champaign. Mr. Su's dissertation is on "Computer analysis of internal fracture filling related to forces of friction." On January 24, 1989, Mr. DuMontelle lectured to the Purdue University Student Chapter of the Association of Engineering Geologists on "Mine Subsidence in Illinois."

Leon R. Follmer presented a lecture on soil genesis to the Midwest Association of Soil Judges conference in Benton, Illinois, October 14, 1988. From October 21 to 23, 1988, he led a field trip to Memphis, Tennessee, to examine loess deposits of the Mississippi valley for the Geography 304 class at the University of Illinois. During the spring semester of 1989 he collaborated with Professor W. Hilton Johnson of the University's Geology Department in teaching a graduate seminar on Quaternary Geology. Dr. Follmer is extensively involved in graduate education in several departments at the University of Illinois and elsewhere throughout the world. He is currently advising one M.S. and four PH.D. students in the geology department, one M.S. and two

Ph.D. students in the geography department, and one M.S. and two Ph.D. students in the agronomy department at the University of Illinois; three M.S. students in the geology department at Southern Illinois University-Carbondale; a Ph.D. student in geology at Philipps University, Marburg, Germany; and a Ph.D. candidate from Xian, China, in the Laboratory of Loess and Quaternary Geology, Academia Sinica. Dr. Follmer is a member of the graduate faculty of the Departments of Geology and Geography and a collaborator with the College of Agriculture at the University of Illinois. He is an Adjunct Professor of Geology at Southern Illinois University-Carbondale.

Anne M. Graese and John P. Kempton advised David Schumacher of Northern Illinois University and Marcia Schulmester of Michigan State University in their thesis research on aspects of northeast Illinois geology.

David L. Gross and Kristin Dean of SSC for Illinois, Inc., conducted a tour of European particle accelerator installations in Germany and Switzerland for 8 newspaper writers and a television crew. The tour was arranged to provide information for the public about the impacts of tunnelling in heavily urbanized areas. Dr. Gross also attended the Tri-State Geological Field Trip, October 14-15, 1988 and spoke at the annual banquet about the state's SSC siting studies.

Ardith K. Hansel presented two lectures on October 21, 1988 at the University of Wisconsin-Parkside: "Glacial history of the Chicago area" for a glacial geology class and "Glacigenic sequences at Wedron, Illinois" for the Geology Department seminar. The next day she led a field trip for 12 students and faculty to several significant Pleistocene outcrops in northeastern Illinois.

Paul C. Helgold served on the review board for the Master of Science thesis of graduate student T. Zychinski for the Geology Department, University of Illinois at Urbana-Champaign.

Randall E. Hughes and Duane M. Moore provided thesis consultation for 10 graduate students, mostly from the University of Illinois Urbana-Champaign campus. They also meet regularly with a local student-faculty clay minerals discussion group.

Russell J. Jacobson led a fossil collecting field trip to southern Illinois localities for the Urbana Park District. About 20 adults and children participated in the field trip. He also presented a talk on the ecology of dinosaurs and the collecting of dinosaurian fossils for a grade school class in Urbana.

Myrna M. Killey presented the lectures, "Landslide Analysis and Slope Stability in Illinois," and "Geotechnical Site Investigation for a 7-GeV Synchrotron at Argonne National Laboratory," to a science seminar at Monmouth College, Monmouth, Illinois, on November 11, 1988. At the Geological Society of America meeting in Denver, Ms. Killey served as a resource geologist for a special field trip for minority middle school earth science students arranged by the Association of Women Geoscientists.

Dennis R. Kolata is a member of graduate student research advisory committees for students from Northern Illinois University, the University of Cincinnati and the University of Illinois.

Chao-Li Liu and the staff of the Radiocarbon Dating Laboratory provided more than 60 radiocarbon dates free of charge during the year for graduate students whose requests had been approved by the Radiocarbon Dating Committee of the Illinois State Geological Survey.

E. Donald McKay III is a member of the thesis advisory committee for George D. Graettinger for the Department of Geography, University of Illinois-Urbana-Champaign.

Rodney D. Norby is a member of the Ph.D. research advisory committee for Joseph A. Devera in the geology department at Southern Illinois University-Carbondale.

J. Bruno Risatti is a member of advisory committees for two graduate students in the Department of Civil Engineering at Northwestern University and provided advice to a graduate student in the biogeochemistry curriculum at Indiana University.

Massoud Rostam-Abadi is a member of the research advisory committees for both a masters and a Ph.D. candidate in the Civil Engineering Department of the University of Illinois at Urbana-Champaign. He has also provided research advice informally for graduate students studying coal combustion in the Department of Mechanical Engineering.

William R. Roy presented two lectures and a help session on solubility modeling by computer-assisted thermodynamic models for the class in Soil Chemistry, Department of Agronomy, University of Illinois at Urbana-Champaign in May 1989.

Christopher J. Stohr accompanied an Urbana Junior High School class on a geology field trip during the fall of 1988 and taught two classes on satellite imagery and remote sensing for 8th and 9th grade classes at University High School, Urbana.

Offices/Committee Memberships/Services in Professional Societies

Terri Adams is a member of the newsletter committee of the Illinois Association of Environmental Professionals.

H. Wayne Bang reviews papers for the Society of Petroleum Engineers and served as a referee for the society's student paper contest.

Margaret H. Bargh served as Secretary/Treasurer of the Illinois Basin Section, Computer-Oriented Geological Society from July 1987 to October 1988.

Robert A. Bauer reviewed manuscripts for the Journal of Environmental Quality and the Journal of Preservation Technology.

James W. Baxter is a member of the Research Council of the Society of Mining Engineers and served on the Mining Engineering Committee of SME from 1986 to 1989. He is a reviewer of contributions on industrial minerals for the society's journal, *Mining Engineering*.

Ross D. Brower serves the Midwest Groundwater Conference as Historian. He is currently Vice President of the Illinois Groundwater Association and served as director until October 1988.

Richard A. Cahill is the Survey's representative to the University of Illinois chapter of Sigma Xi, the national scientific honorary society.

Keros Cartwright is a member of the Ad Hoc Committee on Stratigraphic Nomenclature, the Committee to name the Birdsall Distinguished Lecturer and the Organizing Committee for the 1989 Annual Meeting for the Hydrogeology Division of the Geological Society of America.

Chen-Lin Chou has served as co-editor of Geological Society of America Special Paper Number 248 entitled, "Recent Advances in Coal Geochemistry." The book is currently in press at the Geological Society of America and is slated for release in late 1989 or early 1990. He also reviewed a paper for the International Journal of Coal Geology.

Michael J. Chrzastowski reviewed a manuscript submitted for publication in the journal "Marine Geology."

Dennis D. Coleman reviewed manuscripts for the journals *Chemical Geology*, *Geology*, and the GSA *Bulletin*.

Charles Collinson has been an associate editor for the Illinois State Academy of Science since 1984. He is also chairman of the Research Advisory Committee for the Illinois-Indiana Sea Grant Program for 1988-1989. In that position, he critically reviewed 15 research proposals. He also served as a session moderator and discussant for the Sea Grant workshop on Lower Lake Michigan Research Needs held May 25 in the Trustees' Board Room at the University of Illinois-Chicago.

Joan E. Crockett served as Secretary of the Illinois Geological Society until September 1988 when she became Vice President. In that capacity she has planned the monthly meetings of the Society and coordinated sales of the Society's joint publication with the Indiana-Kentucky Geological Society.

Heinz H. Damberger serves as Program Chairman for the Illinois Mining Institute. He also served as chairman of the Rock Mechanics Award Committee of the Society of Mining Engineers - American Institute of Mining, Metallurgical and Petroleum Engineers through December 1988. He is a member of the editorial board of the International Journal of Coal Geology. In that capacity, he reviewed three manuscripts for that journal. He also reviewed manuscripts for the *Journal of Geology*, the *Bulletin of the Geological Society of America*, and *Geology* and three research proposals submitted to the GSA.

Ilham Demir reviewed a manuscript for the journal, *Geochimica et Cosmochimica Acta*.

Donald R. Dickerson is Past President of the Illinois State Academy of Sciences and Co-Chairman of the Academy's Science Talent Search Committee. In that capacity he judged 45 scientific papers submitted by high school seniors and guided the selection of prize winning and honorable mention papers, the selection of the Frank H. Reed Memorial Award for the best scientific paper in the Westinghouse Science Talent Search and the selection of two winners of the American Association for the Advancement of Science Awards. At the annual banquet of the Junior Academy of Sciences on May 12, 1989 he presented the awards to the winners. Dr. Dickerson is a member of the Board of Directors of the Illinois Junior Academy of Sciences and serves both as the Junior Academy's representative to the State Academy of Sciences and as the State Academy's official Delegate to the Junior Academy. He is campus coordinator for the scientific paper sessions for the Junior Academy's State Science Fair held at the University of Illinois on May 12-13, 1989, and served both as a project judge and as an auditor for "Outstanding" awards for the science fair. Dr. Dickerson also is a member of the editorial board of *Water Resources Journal*.

William G. Dixon, Jr. is an editor of *AEG News*, the newsletter of the North Central Section of the Association of Engineering Geologists and a member of the Section's Nominating Committee. He served as Chairperson of the Bylaws Committee of AEG until November 1988. He is currently secretary of the Illinois Association of Environmental Professionals and was Chairperson of the IAEP's Bylaws Committee throughout 1988.

Paul B. DuMontelle has served as a member of the Board of Directors of the Association of Engineering Geologists (AEG) since October 1987 and is currently chair of the North Central Section of AEG. He is a short-paper editor for the AEG Bulletin and a member of the Screening Committee of the Illinois-Indiana Section of the American Institute of Professional Geologists. In May 1989, he reviewed outstanding science projects in the Earth Science category at the Illinois Junior Academy of Sciences and presented special awards provided by the AEG and the Illinois-Indiana Section of AIPG. He also reviewed abstracts for the AEG's annual awards program in April 1989.

Henry P. Ehrlinger III is Chairman-Elect of the Industrial Minerals Division of the Society of Mining Engineers-American Institute of Mining, Metallurgical and Petroleum Engineers. He organized a conference on Grinding of Industrial Minerals sponsored by SME to be held in Asheville, North Carolina, on September 27-29, 1989. In October 1988, he visited Marquette

University as part of an Engineering School accreditation team. Since the 23rd Forum on the Geology of Industrial Minerals was held in Illinois in April 1987, he has continued to serve as treasurer of that meeting, managing the funds until the proceedings volume is published.

J. James Eldel has been serving as a member of the Membership Committee of the Society of Exploration Geologists (SEG) and was recently elected a trustee of the Society of Economic Geologists Foundation. He is serving on the SEG's Ad Hoc Committee on National Geological Mapping Problems and Needs.

Leon R. Follmer is president of the North American Loess Working Group and secretary-treasurer of the Paleopedology Commission of the International Union for Quaternary Research. He is also a member of the Committee on Geology and Soils of the Geological Society of America and co-chairman of the Illinois Quaternary Association. He serves on the editorial board of the journal, *Catena*, and on the International Editorial Advisory Board of the *Journal of Quaternary Science*.

Keith C. Hackley reviewed a manuscript for the Geological Society of America intended for publication as a GSA Special Paper.

Ardith K. Hansel is a councilor representing historical geology and stratigraphy for the American Quaternary Association (AMQUA). She also serves as a Corresponding Member of the Subcommission on North American Stratigraphy and of the Subglacial Processes and Sediments Working Group of the Commission on Formation and Properties of Glacial Deposits of the International Quaternary Association. During the year she reviewed manuscripts for the *Journal of Sedimentary Petrology*, *Arctic and Alpine Research*, the Ohio Academy of Sciences, *Geology*, and a GSA Special Paper.

Richard D. Harvey is a member of the Council of the Society for Organic Petrology. Since 1985, he has chaired the Subcommittee on Classification of Coal of the Committee on Coal and Coke (D-5) of the American Society for Testing and Materials.

Bruce R. Hensel is an apprentice reviewer for the journal, *Ground Water*.

Beverly L. Herzog is a member of Subcommittee D18.21 on Groundwater and Vadose Zone Monitoring of the American Society for Testing and Materials. In that capacity she attended meetings on June 26-27, 1989, and reviewed seven packages of proposed standards. For the Association of Ground Water Scientists and Engineers, Ms. Herzog is the only person who serves as a member of the editorial boards for both *Ground Water* and *Ground Water Monitoring Review* and, in that capacity, reviewed ten papers. She also provided technical reviews of papers for the American Society of Civil Engineers and the American Water Resources Association. She serves as newsletter editor for the Illinois Groundwater Association.

Richard H. Howard is a member of the Geological Committee of the Illinois Oil and Gas Association and supplies the data for selection of the Association's "Wildcatter of the Year" award.

Bryan G. Huff compiled the 3-, 6- and 10-year reviews of discoveries and crude oil reserve estimates for the American Association of Petroleum Geologists Committee on Statistics of Drilling. He also prepares the annual Illinois stripper well report for the Interstate Oil Compact Commission.

Randall E. Hughes is a councilor of the Clay Minerals Society and a member of the Nominations and Publicity Committees of that society. He also serves as an associate editor of the society's journal, *Clays and Clay Minerals*, and in that capacity, reviewed 13 manuscripts and a 725-page book. As a member of the Mining Engineering Committee for the Society of Mining Engineers (SME) of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), he organized the annual commodity write-ups on clays and barite. He also serves on the

Technical Committee of SME. He continues to serve as editor for the Proceedings of the 23rd Forum on the Geology of Industrial Minerals.

Russell J. Jacobson served a fifth and final term as newsletter editor of the Illinois-Indiana Section of the American Institute of Professional Geologists. He was also president of the Illinois Basin Section of the Computer Oriented Geological Society. That large section decided to dissolve itself during the year and to split into smaller localized sections so that members can attend meetings with minimal travel.

John P. Kempton reviewed two manuscripts submitted to *Geology.*

Latif A. Khan is a member of the organizing committee for the 1990 National Symposium on Mining, Hydrology, Sedimentation, and Reclamation and attended a meeting of that committee. He is also a member of the Technical Papers Subcommittee of the Society of Mining Engineers (SME).

Myrna M. Killey served as president-elect, and chair of the membership and regulatory and legislative committees of the Illinois-Indiana Section of the American Institute of Professional Geologists until December 1988 when she took office as president of the Section. She also serves as liaison between the AIPG section and the North Central Section of the Association of Engineering Geologists.

Robert J. Krumm is assisting Dr. Richard Stenstrom, first vice president of the National Association of Geology Teachers, in organizing a symposium for the 1989 Geological Society of America meeting in St. Louis, Missouri.

Timothy H. Larson provided a technical review for a manuscript submitted to *Water Research* the journal of the International Association of Water Pollution Research and Control.

Chao-Li Liu provided technical reviews for two manuscripts for the Geological Society of America. He also reviewed a research proposal for the Texas State Natural Resource Board.

John M. Lytle is a technical reviewer for the journal, *Fuels Processing Technology.* He also organized and chaired a technical session at the Engineering Foundation Conference, Santa Barbara, California, January 23-27, 1989.

John M. Masters is a member of the Educational Issues Committee of the Society of Mining Engineers (SME) of the American Institute of Mining, Metallurgical and Petroleum Engineers. He also reviewed a paper on industrial minerals submitted to the SME's journal *Mining Engineering.*

John M. Masters and Philip C. Reed are judging co-chairmen for the Earth Sciences Division of the Illinois Junior Academy of Sciences State Science Fair held in Champaign each May. Scientists from the Illinois State Geological Survey who assisted at the fair on May 13 this year included **Jonathan H. Goodwin, Randall E. Hughes, Russell J. Jacobson, Donald A. Keefer, Myrna M. Killey, Ivan G. Krapac, Nicholas P. Schnelder, Wen-June Su, C. Brian Trask, and Stephen T. Whitaker, Lawrence Wu, and John D. Yeko.**

Michael V. Miller is a member of the Mapping and Resource Information Committee of the National Association of Wetlands Managers.

Duane M. Moore is a chairman of the Publicity Committee of the Clay Minerals Society.

Rodney D. Norby provided technical reviews of manuscripts for the Paleontological Society. He also reviewed a proposal for the University of Illinois Campus Research Board.

Donald F. Oltz represented the Illinois State Geological Survey on the Program Development Committee and the Technical Project Ranking Subcommittee of the Geoscience Institute for Oil and Gas Recovery Research. He is a member of the Institute's Committees on Technical Programs and Reservoir Characterization. In that capacity he has attended Board meetings, technical forums and the Institute's liaison meeting with the U.S. Department of Energy and the U.S. Geological Survey. For the American Association of Petroleum Geologists, Dr. Oltz serves on the Research Committee. He also represents the state of Illinois on the Association's Membership Committee and the Committee on the Statistics of Drilling. He chairs the Scholarship Committee for the Illinois Geological Society.

Russell A. Peppers is a member of the Working Group on Midcontinent Pennsylvanian Stratigraphy of the Society of Economic Paleontologists and Mineralogists and the Subcommission on Middle Pennsylvanian Stratigraphy of the Commission of Pennsylvanian Stratigraphy of the International Committee on Carboniferous Stratigraphy.

Vickie L. Poole served as co-editor for the fall 1988 and editor of the spring 1989 newsletters for the Illinois Groundwater Association.

Philip C. Reed is a member of the editorial board of the journal, *Ground Water*, of the National Water Well Association.

J. Bruno Risatti is a member of the Precambrian Paleobiology Research Group of the Center for Evolution and the Origin of Life, University of California-Los Angeles. He also reviewed five manuscripts for various journals.

William R. Roy reviewed a total of five manuscripts for the *Journal of Hazardous Materials*, the Soil Science Society of America journal, and *Environmental Science and Technology.*

Rodney R. Ruch is chairman of Subcommittee 5—Solid Fuels: Methods of Analysis, Committee TC27 of the International Standards Organization. He is also a member of Committee D5 on Coal and Coke of the American Society for Testing and Materials.

Michael L. Sargent serves as the Geological Society of America's institutional representative at the Illinois State Geological Survey.

Paul R. Seaber is a second vice-chairman of the Hydrogeology Division of the Geological Society of America, and co-chairman of the Division's Program and Hydrostratigraphic Units Committees. He is one of three editors for the volume on hydrogeology in the GSA's "Decade of North American Geology" series. In 1989, he was elected the GSA's representative to the North American Commission on Stratigraphic Nomenclature. At the Society's annual meeting in Denver, Colorado, October 31-November 3, 1988, he made formal proposals for inclusion of hydrostratigraphic units in the North American Code of Stratigraphic Nomenclature.

Beverly Seyler is a member of the Board of Directors of the Illinois Geological Society.

Christopher J. Stohr chairs the Remote Sensing Committee of the Association of Engineering Geologists and is an editor of the newsletter of the North Central Section of AEG. Mr. Stohr was the Illinois representative in the Western Great Lakes Region of the American Society for Photogrammetry and Remote Sensing until the fall of 1988 when his term expired. For the Society he is a member of the Engineering Applications Committee, Remote Sensing Applications Division and a member of the Autometric Award Committee. He also reviewed a manuscript for the Society's journal *Photogrammetric Engineering and Remote Sensing.*

Wen-June Su is an editor of the newsletter of the North Central Section, Association of Engineering Geologists. He also served as a reviewer of student research abstracts for the section.

Colin G. Treworgy served on the President's Prize committee of the International Association of Mathematical Geologists.

Stephen T. Whitaker is an official delegate to the American Association of Petroleum Geologists from the Illinois Geological Society.

CONTRIBUTIONS TO OTHER GOVERNMENT AGENCIES

Testimony/Informational Presentations to Local/State/National Committees

Robert A. Bauer, Keros Cartwright, David L. Gross, John P. Kempton, and Morris W. Leighton presented testimony at a U.S. Department of Energy hearing on the draft environmental impact statement for the proposed SSC site in Illinois, in Oswego, Illinois, on October 6, 1988.

Dwain J. Berggren provided technical review for a proposal submitted to the Water Resources Center, University of Illinois.

Richard A. Cahill and Jonathan H. Goodwin prepared written testimony on "Applications of Geology to Mapping of the Potential for Radon Gas Emanation" for presentation to the U.S. House of Representatives, Subcommittee on Oversight and Investigation, Committee on Interior and Insular Affairs.

Michael J. Chrzastowski received a letter of commendation from David W. Folger, coordinator of Great Lakes Studies for the U.S. Geological Survey, thanking him for negotiating arrangements for boat moorings, project staging areas and other facilities that saved the U.S. Geological Survey several thousands of dollars in operating costs and assured efficient completion of the two-week sidescan sonar survey at Indiana Shoals.

Charles Collinson is a technical advisor for the Lake Bluff Citizens Lakeshore Advisory Committee and conferred with them on four occasions during the year. On October 15, 1988, Dr. Collinson participated in a public meeting on lakeshore planning sponsored by the Chicago Planning Commission Committee on Lakeshore planning held at the Crown Center of the Loyola University Lakeside Campus. On November 17, 1988, Dr. Collinson presented testimony to the City of Chicago Committee on zoning regarding the advisability of approving the proposed Loyola University lakefill. He also presented testimony concerning the proposed lakefill on March 10, 1989, at a public hearing called by the Chicago District, U.S. Army Corps of Engineers, Illinois Pollution Control Board, Illinois EPA, and Illinois Department of Transportation - Division of Water Resources.

Paul B. DuMontelle presented information about mine subsidence in the East St. Louis area to the Judiciary Committee of the Illinois House of Representatives at the request of Representative Wyvetter H. Younge. He also provided technical review for proposals submitted to the Illinois Mining and Mineral Resources Research Institute at Southern Illinois University at Carbondale.

J. James Eidel was selected as one of two representatives of the Mineral and Energy industries at a meeting of 38 scientists at Stanford on August 1-4, 1988 requested to advise the USGS-NSF-DOE Interagency Coordinating Group preparing a draft response to Congress required under provisions of the Continental Scientific Drilling and Exploration Act. For this he prepared a 16-page formal testimony on "Mineral Resource Problems Requiring Continental Scientific Drilling" and addressed the members of the Interagency Coordinating Group on August 3, 1988. The final report of the Stanford panel, "The Role of Continental Drilling on Modern Earth Sciences--Scientific Rationale and Plan for the 1990s" was attached as an appendix to the Interagency Committee's response to Congress.

David L. Gross presented testimony and information to various committees involved with the SSC siting process during the summer and fall of 1988 including: briefings for the Governor's SSC Task Force on July 19 and 28; talks to the Board of SSC for Fermilab, Inc., on August 8 and September 6; a briefing for the staff of the Illinois congressional delegation on October 3 and a portion of the state's presentation to the Secretary of Energy on October 6 in Washington, DC.; a briefing for the staff of the Metropolitan Sanitary District of Greater Chicago on November 4 and a debriefing session on the SSC siting decision in Washington, DC., on December 7.

Bruce R. Hensel presented the results of the research project "Numerical Estimates of Potential for Groundwater Contamination from Land Burial of Municipal Wastes in Illinois," to the Illinois Pollution Control Board in Springfield, June 20, 1989. He also provided technical review for a research proposal submitted to the Water Resources Center of the University of Illinois.

Bryan G. Huff prepared the annual report on the quantity and value of natural gas produced in Illinois for the Energy Information Administration of the U.S. Department of Energy. He also prepared an 8-page briefing paper profiling the Illinois oil and gas industry for a visit of Congressman Terry Bruce.

Donald A. Keefer discussed preliminary maps of Priority Recharge Areas and reviewed the methods by which they were compiled for the Interagency Coordinating Committee on Groundwater in Springfield, March 7, 1989.

John P. Kempton discussed the Mahomet-Teays Valley aquifers at a public meeting in Argenta, Illinois, January 23, 1989, for citizens concerned about the proposed Decatur well field nearby.

Timothy H. Larson provided a technical review for a proposal submitted to the Hazardous Waste Research and Information Center.

John M. Masters reviewed a paper by James Hill of the U.S. Bureau of Mines on the "Mineral Industries of Illinois in 1987."

Dennis P. McKenna discussed "Geology for Planning" for the Wayne County Citizens Review Committee meeting in Fairfield, Illinois, September 8, 1988. On September 12, 1988, he reviewed Illinois Department of Energy and Natural Resources' activities that respond to the mandate on pesticides in groundwater in the Groundwater Protection Act for the Interagency Coordinating Committee on Groundwater in Springfield, Illinois.

Philip C. Reed and colleagues from the Illinois State Water Survey presented talks on hydrogeology, geophysical exploration methods, and other subjects related to groundwater production for public meetings at the Aviston Village Hall, January 25, 1989 and at a church south of Dieterick on February 23, 1989. Later in the spring, meetings were held at the State Water Survey to discuss potential sources of large municipal groundwater supplies in the Effingham-Edgewood-Mason areas of Effingham County. Mr. Reed met again with representatives of Aviston and the St. Rose Water District on May 2, 1989 to discuss the availability of groundwater in the Clinton County area.

William R. Roy reviewed research proposals for the U.S. Department of Energy and the University of Illinois Campus Research Board.

Richard H. Shiley presented information about the status of the carbon monoxide-ethanol demonstration project for Senator Stanley Weaver and Representatives Helen Satterthwaite and Timothy Johnson in response to an inquiry. He also reviewed a research proposal for the University of Illinois Campus Research Board.

Christopher J. Stohr reviewed a research proposal for the Hazardous Waste Research and Information Center.

Testimony/Informational Presentations for Civil/Criminal Court Proceedings

Michael J. Chrzastowski provided published sidescan sonar information about Chicago shore defense structures in response to a telephone and letter request from attorneys representing the plaintiff in a civil suit.

William G. Dixon, Jr., Vickie L. Poole, and Walter J. Morse used a magnetometer survey on June 28, 1988, to assist the Blue Island police department and State Police divers in attempting to locate and retrieve a car from the murky waters of the Calumet Sag Channel. According to an anonymous tip, a car containing the body of a woman missing since the previous August had been dumped in the Sag Channel. Based on the magnetometer anomalies, a car was successfully retrieved from the Sag Channel, although not the missing woman's car. Ironically, the car retrieved approximately matched the description of the missing woman's vehicle, but had been stolen in Chicago in 1984.

Bryan G. Huff has provided copies of records and other information about oil wells in western Illinois to the Attorney General of Pennsylvania.

Membership/Participation in Local/State/National Government Advisory Committees

James W. Baxter represented the Illinois State Geological Survey and presented information during mediation of appeals to the U.S. Forest Service's ten-year plan for the Shawnee National Forest in southern Illinois.

Richard C. Berg addressed the Governor's Groundwater Advisory Council on Recharge Area Mapping at the Council's meeting in Naperville, Illinois, December 1, 1988. Other Survey staff who attended the Groundwater Policy Forum included **Terri Adams, William S. Dey, and Donald A. Keefer.** In March 1989, Dr. Berg provided information to the Interagency Coordinating Committee on Groundwater about the current status of the Geological Survey's Groundwater Protection research activities. He serves the ICCG as a technical advisor and attends their bi-monthly meetings. He also served on the Illinois Department of Nuclear Safety's Technical Advisory Committee until the committee was disbanded in December 1988, and now attends the weekly meetings of the Technical Advisory Committee for the Martinsville Low-Level Waste Disposal Alternative Site for Battelle Memorial Institute, the prime contractor to DNS. He is also a member of the McHenry County Technical Advisory Committee for Waste Disposal.

Ross D. Brower served on the Illinois EPA's ad hoc Underground Injection Control advisory committee from July through September 1988. He was present, but was not called to testify at a hearing for the Class I Injection Well permit for Allied Signal Corporation held by the Illinois EPA in Danville, Illinois, in August 1988.

Richard A. Cahill serves as the Survey's facility coordinator for the Illinois Emergency Services and Disaster Agency under the provisions of Title III of the Superfund Amendment and Reauthorization Act. He is also a member of the Illinois response team for radiological accidents for ESDA. He has also qualified under Round 5 of the U.S. EPA's National Radon Measurement Proficiency Program.

Keros Cartwright is a member of the State's Interagency Coordinating Committee on Groundwater; the Science Advisory Board of the U.S. Environmental Protection Agency, and the Groundwater Research Review panel of the U.S. Department of Energy.

Chusak Chaven is a member of the International Staff/Student Advisory Committee under the Office of the Chancellor of the University of Illinois at Urbana-Champaign.

Michael J. Chrzastowski provided technical review for a proposal submitted to the Michigan Sea Grant college program.

Dennis D. Coleman provided technical review of research proposals for the University of Illinois Research Board and for the National Science Foundation. Other Survey staff who reviewed proposals for NSF included **Robert A. Bauer, Heinz H. Damberger, Paul C. Heigold, Dennis R. Kolata, and Rodney D. Norby.**

Charles Collinson chaired the Technical Review Committee for the Chicago Loyola University Lakefront Development Project. In that capacity, he reviewed technical studies and reports prepared by various contractors and prepared reports on the data, model testing procedures and probable impact on coastal processes of the proposed 20.4-acre lakefill. Until August 1988, he was also a member of the Technical Review Committee for the Rosewood Beach Shore Development Project. He is currently a member of the shoreline mapping advisory group of the Chicago Park District.

Paul B. DuMontelle is president of the Boneyard Creek Commission of Champaign-Urbana. In that position he testified before the Champaign City Council in September 1988, and chaired monthly meetings of the commission. As Vice-Chairman of the Illinois Mapping Advisory Committee, Mr. DuMontelle participated in the meetings of the Committee in Springfield, March 10, 1989 and in Champaign, June 23, 1989.

J.James Eidel is a member of the Interagency Wetlands Advisory Committee chaired by the Illinois Department of Conservation.

Leon R. Follmer is a member of the University of Illinois Committee on Reclamation of Mined Land and Mine Refuse.

David L. Gross is the State's voting representative and **E. Donald McKay III** is a member of the Advisory Board of the Computerized River Information Center of the U.S. Fish and Wildlife Service, LaCrosse, WI. They travelled to LaCrosse and hosted a meeting of the Advisory Board in Champaign. **Robert J. Krumm, Robert R. Pool and Lisa R. Smith** also attended the meeting in Champaign. Mr. Krumm made a presentation on the use of the GIS for the Champaign County landfill site screening project and Ms. Smith reviewed the GIS process used to screen the state for potential sites for the low-level radioactive waste disposal facility.

Ardith K. Hansel provided technical review for a research proposal submitted to the National Geographic Society.

Paul C. Heigold technically reviewed a research proposal submitted to the Lindbergh Fund.

Beverly L. Herzog is a technical advisor for the Citizens' Advisory Group on the closure of the Sheffield low-level radioactive waste disposal site. She also provided technical reviews for three proposals submitted to the Water Resources Center of the University of Illinois.

Richard H. Howard is a member of the Enhanced Recovery Committee of the Interstate Oil Compact Commission and of the Potential Gas Committee.

Randall E. Hughes is a member of the Board of the Southwestern Illinois Metropolitan Planning Area Commission (SWIMPAC) for their study of the potential for production of fired clay products in the area. **Robert J. Krumm, Gail D. Taylor, Duane M. Moore** and he worked together to compile maps and other geologic information used by SWIMPAC in a publication released in September 1988 summarizing the results of their investigation.

Russell J. Jacobson is a member of the Tri-State Committee on Correlations in the Pennsylvanian System of the Illinois Basin.

Donald A. Keefer provided technical review for two proposals submitted to the Water Resources Center, University of Illinois.

Myrna M. Killey and C. Brian Trask have provided technical advice to the Intergovernmental Solid Waste Disposal Association of Champaign County.

Carl W. Kruse was one of eleven members of a U.S. Department of Energy Coal Liquefaction Research Needs Assessment Panel organized by Science Applications International, Inc., under a contract with the Branch of Program Analysis, Office of Energy Research. Dr. Kruse also serves on the proposal review panel of the Department of Energy's Small Business Innovation Research Program and reviewed two proposals.

Morris W. Leighton served as a member of the Committee Advisory to the U.S. Geological Survey, a committee sponsored by the National Academy of Sciences, National Research Council. He was appointed as Advisor, Governor's Science Advisory Council. He also serves as Secretary to the Coal Advisory Committee to the Illinois State Geological Survey, member of the Research Committee of the Interstate Oil Compact Commission, Statistician for the Association of American State Geologists, and member of the Liaison Committee of that association.

E. Donald McKay III represents the Geological Survey on the Oversight Committee for the Lands Unsuitable for Mining Program and the Illinois Geographic Information System Committee. He also represented the Survey on the Illinois Natural Resources Information System Committee until it was dissolved during the reporting period. He is also a member of the GIS Design Committee for the Mid-Continent Herbicide Initiative of the U.S. Geological Survey. Dr. McKay presented an illustrated lecture and discussion on the procedures used for regional screening for the low-level radioactive waste disposal facility for a public meeting of the Wayne County Ad Hoc Committee on Radwaste Disposal in Fairfield, Illinois, September 1988.

Dennis P. McKenna is a member of the Oversight Committee for the Mid-Continent Herbicide Initiative of the U.S. Geological Survey's Water Resources Division and attended meetings of the committee on February 7-8, April 27-28, and May 30-31, 1989. He also serves as one of the technical advisors for the Mason County Water Issues Committee and met with the Committee on June 15, 1989. He provided technical review for five proposals submitted to the Water Resources Center of the University of Illinois and for one proposal submitted to the Department of Energy and Natural Resources.

Edward Mehnert is a member of the Research Advisory Committee of the Hazardous Waste Research and Information Center. He is also a member of the Underground Injection Control Technical Advisory Committee of the Illinois Environmental Protection Agency. The Committee, which reviews technical aspects of UIC permits, land ban petitions, and injection well monitoring and testing, held nine meetings during the report period.

Michael V. Miller is a member of the Watershed Priority Committee chaired by the Illinois Department of Agriculture and an alternate member of the Interagency Wetlands Advisory Committee chaired by the Illinois Department of Conservation. He regularly attends the meetings of the State Water Plan Task Force chaired by the Division of Water Resources, Illinois Department of Transportation.

Donald F. Oltz is a member of the Energy Resources Committee and the Subcommittee on Environment of the Research Committee for the Interstate Oil Compact Commission. He reviewed proposals for the Hazardous Waste Research and Information Center and the U.S. Department of Energy. He also participated in the meetings that developed the Illinois Basin Consortium.

Nicholas P. Schneider attended the Environmental Impact Statement hearings on the site for the superconducting super collider in Waxahachie, Texas, in September 1988.

Paul R. Seaber is a member of the Groundwater Quantity Committee of the State Water Plan Task Force and made presentations to the Committee on aquifers in Illinois, saltwater intrusion in Illinois, subsidence in Illinois, and resource assessment-yield factors. He served on the grant committee of the Hazardous Waste Research and Information Center until March 1989 when his term ended. He is currently a member of the Technical Advisory Committee for the U.S. Geological Survey Water Resources Division investigation of the Upper Illinois River Basin in Illinois, Indiana and Wisconsin under the National Water Quality Assessment Program.

Christopher J. Stohr represents the Chief as secretary of the Illinois Mapping Advisory Committee. He organized and participated in the symposium, "Remote Sensing and Its Applications," in January 1989, and the symposium on soil surveys on June 23, 1989, in Champaign sponsored by the Illinois Mapping Advisory Committee. He serves as a member of the University of Illinois Aerial Photography and Remote Sensing Committee.

C. Brian Trask chairs the Champaign City Council's Environmental Advisory Commission.

Billy A. Trent attends meetings and takes the minutes for meetings of the Technical Committee and the Advisory Board of the Illinois Mine Subsidence Research Program.

Lawrence Wu attends the meetings of the Illinois Coal Development Board.

CONTRIBUTIONS TO THE PUBLIC AND INDUSTRY

Popularized Addresses/Presentations for Civic Groups/Public Meetings

Terri Adams was interviewed for a featured side-bar in an article on women in science that appeared in the May issue of *Career World* magazine. She also appeared on the Channel 7 news in Chicago to explain what a seiche is. On June 9, 1989, she spoke to the Earth Science Club of Northern Illinois on the Survey's Lake Michigan bathymetric mapping program.

Margaret Bargh and Colin Treworgy were interviewed by Linda Devocelle of the Illinois Department of Energy and Natural Resources for a radio spot on the subject of coal mines in Illinois.

Ross D. Brower, Jonathan H. Goodwin, Suzanne Muckensturm, David L. Reinertsen, and Edward C. Smith answered questions from the public and handed out leaflets at the groundwater protection exhibit at the state fair in the ENR tent in August 1988.

Robert A. Bauer was interviewed by WSIU-Carbondale for a radio program about the impacts of longwall mining on water wells and agriculture and by Linda Devocelle of ENR for a short radio program on possible damage to building foundations that might occur as a result of the severe drought in the summer of 1988.

Richard C. Berg discussed groundwater protection activities of the Illinois State Geological Survey at a press conference held April 19, 1989, to highlight the Governor's proclamation of May as Groundwater Protection Month in Illinois. He was also interviewed by Pioneer Press and by WAIT radio of Crystal Lake, McHenry County, on groundwater protection activities.

Richard A. Cahill, as the Survey's authority on radon, provided press interviews for the Champaign-Urbana *News-Gazette* and for Sandra Breisch, a free-lance writer preparing an article on radon in the work place.

Keros Cartwright discussed groundwater conditions of the SSC site for the Illinois Pollution Control Federation on July 21, 1988, and made presentations about groundwater hydrogeology in relation to siting of low-level radioactive waste disposal facilities at meetings of the Wayne County

Citizens' Advisory Committee on January 21, 1989 and the Martinsville Citizens' Advisory Committee on February 27, 1989. He also participated in two meetings of the Sheffield Citizens' Advisory Committee.

Sheng-Fu Joseph Chou, Dennis P. McKenna, and John R. Valkenburg provided assistance on January 4, 1989, for the University of Illinois' Department of Agricultural Communication. Videotape shot in the Illinois State Geological Survey's laboratories will be used in a presentation for the pilot study of pesticides in rural private water supplies.

Michael J. Chrzastowski, Charles Collinson, and Ardith K. Hansel made presentations in Chicago, July 28, 1988, on the U.S. Geological Survey/Illinois State Geological Survey cooperative study on southern Lake Michigan shore erosion. As a result, stories about the sidescan sonar studies and other Lake Michigan cooperative research programs appeared in the *Chicago Tribune* on Sunday, July 31, 1988, and in *The Lake Forester* on August 11.

Charles Collinson presented the keynote speech for the Illinois Local Government Conference on Lake Michigan Shoreline Hazards held at the Illinois Beach State Park Lodge on May 25, 1989. Sponsored by the Lake Michigan Federation and the Center for the Great Lakes, the conference was funded by the Ford Foundation and the National Oceanic and Atmospheric Administration.

William S. Dey, Jonathan H. Goodwin, Donald A. Keefer, and David L. Reinertsen answered questions and handed out brochures at a groundwater protection education booth at the Decatur Teacher Conference held at Milikin University, March 22, 1989. Mr. Dey and **Edward Mehnert** served in the same capacity at the Farm Progress Show in West Brooklyn, IL. in October 1988. At the University of Illinois Agronomy Days, June 16, 1989, Mr. Dey spoke on the agricultural chemical pilot study now being conducted by the Geological and Water Surveys.

William G. Dixon, Jr. was among the ENR staff members who handed out brochures and answered questions at a groundwater protection education booth at a meeting of the Illinois Municipal League in the Chicago area, October 8, 1989.

David L. Gross made many presentations about the State's SSC siting efforts to newspaper editorial boards in Indianapolis, August 4; Milwaukee, August 10; St. Louis, August 31; New York, September 1; Chicago, September 2, and Columbus, Ohio, September 7. He also spoke to the Lake County Chamber of Commerce on August 3 and the Urbana Exchange Club on October 19. He also appeared with Jeffrey Miller of the Governor's staff, and Director Witter at a press conference held November 10 to present the State's reaction to the SSC siting decision.

Ardith K. Hansel presented a talk on her activities as a research geologist for the Business and Professional Women's Club of Arthur, Illinois, November 10, 1988. At a meeting of the Illinois Association of Environmental Professionals in Chicago on May 24, 1989, Dr. Hansel discussed the "Ice Age Heritage of Illinois."

Bruce R. Hensel presented the results of several groundwater modeling projects to the Board of the Society for the Illinois Scientific Surveys.

Richard H. Howard was interviewed by Linda Devocelle for an ENR radio spot about the oil play possibilities of sandbars in the Pennsylvanian paleovalley complex.

James R. Jennings presented the lecture, "Pennsylvanian Plant Fossils from Illinois;" **Donald G. Mikulic** spoke on "An Exceptionally Preserved Silurian Biota from Wisconsin," and **Michael L. Sargent** discussed "Meteorite Impact Structures in Illinois" for the Midwest Federated Rock and Mineral Societies meeting in Macomb, Illinois, in July 1988.

John P. Kempton discussed a test drilling program in Tazewell County for a reporter from the *Pekin Daily Times* and provided information about the Mahomet-Teays Valley aquifers for a reporter from the *Decatur Herald and Review*.

E. Donald McKay III presented a slide-illustrated talk, "Geologic Factors for Screening Counties for Landfill Sites Using the Geographic Information System," for public meetings in Champaign, Coles, Crawford, Jo Daviess, La Salle and Madison Counties.

Dennis P. McKenna spoke on a "Pilot Study: Agricultural Chemicals in Rural Private Water Wells," at gatherings of county agricultural agencies in Mason Livingston and Effingham Counties. On January 17, 1989, he spoke on "Potential for Agricultural Chemical Contamination of Groundwater in Iroquois County" for the Iroquois County Crops Clinic in Ashkum. In Newton, Illinois, March 27, 1989 he spoke to the southeastern Illinois Sustainable Agriculture Association on "ISGS Programs Related to Agricultural Chemicals in Groundwater."

Rodney D. Norby was interviewed by John Paul of WCIA-TV on September 22, 1988 on the significance of a mastodon tooth found near Danville. In Danville, William Lowry of WSOY radio and a local stringer for United Press international interviewed Dr. Norby on the significance of an ammonite found near Decatur.

Richard H. Shiley, Kristie K. Brewer, Lawrence Wu, Daniel J. Adomaitis and Conrad Hinckley of SIU mounted a display on the carbon monoxide-ethanol coal desulfurization project in the "Alternative Markets" tent at the Illinois State Fair, August 11-21, 1988.

Robert C. Valden presented a talk on groundwater geology and the proposed Decatur/Argenta well field in Clinton, Illinois, May 24, 1989.

Other Public Services

Daniel J. Adomaitis and Kristi K. Brewer served as judges of research projects and papers at the science fair for Holy Cross Grade School of Champaign, February 13, 1989. **Dwain J. Berggren, William S. Dey and Russell A. Peppers** served as judges for the science fair at Jefferson Middle School in Champaign, January 19, 1989. Mr. Berggren also judged at the University High School science fair, Urbana, March 3. **C. Brian Trask** served as a judge for the Science Fair at Columbia Middle School, March 7, 1989. **Philip J. DeMaris** served as a judge for the Illinois Junior Academy of Sciences regional science fair held at Parkland College, April 8, 1989.

ILLINOIS STATE GEOLOGICAL SURVEY

PUBLICATIONS

July 1988 to June 1989

ILLINOIS STATE GEOLOGICAL SURVEY SERIES
(Released to the Public from July 1, 1988 to June 30, 1989)

Circulars

541 A study of trench covers to minimize infiltration at waste disposal sites - Final Report. **K. Cartwright, T.H. Larson, B.L. Herzog, T.M. Johnson, K.A. Albrecht, D.L. Moffett, D.A. Keefer, C.J. Stohr,** 1989, 88 p., 89 figures, 15 tables, appendix.

542 Stack-unit mapping of geologic materials in Illinois to a depth of 15 meters. **R.C. Berg and J.P. Kempton.** 1988. 23 p., 4 plates.

544 Illinois Basin--A tidally and tectonically influenced ramp during mid-Chesterian time. **Treworgy, J. D.** 1988. 20 p. 12 figures.

Environmental Geology Notes

123 Geological-geotechnical studies for siting the superconducting super collider in Illinois: regional summary. **A.M. Graese, R.A. Bauer, B.B. Curry, R.C. Valden, W.G. Dixon, Jr. and J.P. Kempton.** 1988. 100 p. 3 appendixes, 37 figures, 1 appendix figure, 10 tables, 7 appendix tables.

125 Disposal alternatives for material to be excavated from the proposed site of the superconducting super collider in Illinois. **L.M. Curran, S.B. Bhagwat, and C.A. Hindman.** 1988. 17 p., 5 figures, 5 tables.

128 Preliminary side-scan sonar investigation of shore defense structures along Chicago's northside lakefront. **M.J. Chrzastowski and J.S. Schlee.** 1988. 32 p., 13 figures, 3 tables.

129 Evaluation of groundwater monitoring programs at hazardous waste disposal facilities in Illinois. **B.L. Herzog, B.R. Hensel, E. Mehnert, J.R. Miller and T.M. Johnson.** 1988. i-xii and 86 p., 51 figures, 18 tables.

130 Geochemical interactions of hazardous wastes with geological formations in deep-well systems. **W.R. Roy, S.R. Mravik, I.G. Krapac, D.R. Dickerson and R.A. Griffin.** 1989. i-ix and 52 p., 21 figures, 11 tables, 4 appendixes, 4 appendix figures, 5 appendix tables.

Cooperative Groundwater Reports

11 Agricultural chemicals in rural private wells in Illinois: recommendations for a state-wide survey. **McKenna, D.P., S.C. Schock, E. Mehnert and S.C. Mravik.** 1989. 109 p., 15 figures, 13 tables, 6 appendixes, 2 appendix tables, 2 appendix figures.

Illinois Mineral Notes

100 Illinois mineral industry in 1986 and review of preliminary mineral production data for 1987. **I.E. Samson.** 1989. 40 p., 25 tables, 11 figures.

Illinois Petroleum

129 Hydrocarbon accumulation in a paleovalley at Mississippian-Pennsylvanian unconformity near Hardinville, Illinois: a model paleogeomorphic trap. **R.H. Howard and S.T. Whitaker.** 1988. 26 p., 1 table, 18 figures, 2 appendxes.

130 Silurian pinnacle reef distribution in Illinois: model for hydrocarbon exploration. **S.T. Whitaker.** 1988. 32 p., 1 table, 16 figures, 2 plates.

131 Oil and gas developments in Illinois, 1986. **B.G. Huff.** 1989. 76 p., 8 tables, 2 figures.

132 Catalog of cores from the sub-Galena Group in Illinois. **T.H. Shaw and M.L. Sargent.** 1989. 30 p., 6 figures.

Monthly Drilling Report

621-632 Monthly report on oil and gas drilling in Illinois. **B.G. Huff and R.T. Black.** 1988-1989. approx. 18 pages each.

Coal Mine Map Series

Maps and Directories Extent and location of coal mining operations as of January 1987. **M.H. Bargh, C. A. Morgan and C.G. Treworgy.** 1988. Computer generated 1:100,000-scale maps on paper or polyester film showing locations of all known active and inactive coal mining operations, mined out areas. The Directory for each county lists the location, mine name, company name, type of mine, seam mined and years operated for all mines shown on the map. Data in the directories are keyed to the maps by index numbers. A total of 80 maps cover all 73 counties where coal mining activities have ever occurred. Extra maps* and inset maps are provided to clearly portray activities in multiple coal seams. Counties covered include: Adams, Bond, Brown, Bureau, Calhoun, Cass, Champaign, Christian, Clay, Clinton, Coles, Crawford, Cumberland, Douglas, Edgar, Edwards, Franklin, Fulton, Gallatin*, Greene, Grundy, Hamilton, Hancock, Hardin, Henry, Jackson, Jasper, Jefferson, Jersey, Johnson, Kankakee, Knox, La Salle, Lawrence, Livingston, Logan, Macon, Macoupin, Madison, Marion, Marshall, McDonough, McLean, Menard, Mercer, Monroe, Montgomery, Morgan, Moultrie, Peoria, Perry, Pike, Pope, Putnam, Randolph, Richland, Rock Island, Saline*, Sangamon, Schuyler, Scott, Shelby, Stark, St. Clair, Tazewell, Vermilion*, Wabash, Warren, Washington, White, Will, Williamson*, and Woodford.

Contract/Grant Reports

1988-1 Ultra-fine coal cleaning via explosive shattering and aggregate flotation processes. **R.R. Ruch, G.C. Sresty, R.B. Read, P.J. DeMaris, D.M. Rapp, C.W. Kruse, C. Chaven and M.S. Summers.** 1988. 38 p., 19 tables, 7 figures, 4 appendixes, 2 appendix figures, 2 appendix tables.

Field Trip Guide Leaflets

1988-C A guide to the geology of the Forrest Area. **D.L. Reinertsen, L.R. Follmer, J.M. Masters and P.C. Reed.** 1988. 27 p. 5 figures., 2 appendixes.

1988-D A guide to the geology of the Wolf Lake area, Union and Jackson Counties. **D.L. Reinertsen and P.C. Reed.** 1988. 39 p., 10 figures, 3 appendixes.

1989-A Guide to the geology of the Newton area, Jasper County. **C.P. Weibel, D.L. Reinertsen and P.C. Reed.** 1989. 30 p., 15 figures, 2 appendixes.

1989-B Guide to the geology of the Savanna area, Carroll and Jo Daviess Counties. **D.L. Reinertsen.** 1989. 34 p., 11 figures, appendix.

Reprint Series

1988D A reevaluation of the timing and causes of high lake phases in the Lake Michigan Basin. **A. K. Hansel and D.M. Mickelson.**

1988E Cyclothems in the Carbondale Formation (Pennsylvanian: Desmoinesian Series) of La Salle County, Illinois. **C. B. Trask.**

1988F Fluvial-deltaic deposits (Caseyville and Abbott Formations) of Early Pennsylvanian age exposed along the Pounds Escarpment, southern Illinois. **R.J. Jacobson.**

1988G Horseshoe Quarry, Shawneetown Fault Zone, Illinois. **W. J. Nelson.**

1988H Size and maceral association of pyrite in Illinois coals and their float-sink fractions. **R.D. Harvey and P.J. DeMaris.**

1988I Illinois: description of coal seams. **H.H. Damberger.**

1988J Origin of clay minerals in Pennsylvanian strata of the Illinois Basin. **R.E. Hughes, P.J. DeMaris, W.A. White and D.K. Cowin.**

1988K Organic geochemistry of ten samples of Anna and Energy Shale Members of the Carbondale Formation (Pennsylvanian), Illinois Basin. **M.-I. Chou, C.-L. Chou and R.A. Allen.**

1988L Ramp-platform model for Silurian pinnacle reef distribution in the Illinois Basin. **Stephen T. Whitaker.**

1988N Flash pyrolysis of coal, coal maceral, and coal-derived pyrite with on-line characterization of volatile sulfur compounds. **M.-I. Chou, M.A. Lake and R.A. Griffin.**

1988O Changes in volatile organic chemical concentrations after purging slowly recovering wells. **B.L. Herzog, S.-F.J. Chou, J.R. Valkenburg and R.A. Griffin.**

1988Q Mapping thermal soil properties in Illinois, USA. **T.H. Larson**

1988R Infiltration through layered soil trench covers: response to an extended period of rainfall. **T.H. Larson, D.A. Keefer, K.A. Albrecht and K. Cartwright.**

1989A The Illinois Basin Coal Sample Program: status and sample characterization. **R.D. Harvey and C.W. Kruse.**

1989B Infiltration and hydraulic conductivity of a compacted earthen liner. **K.A. Albrecht and K. Cartwright.**

1989C Investigation of failure mechanisms and migration of organic chemicals at Wilsonville, Illinois. **B.L. Herzog, R.A. Griffin, C.J. Stohr, L.R. Follmer, W.J. Morse and W.-J. Su.**

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